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Ground Robotics Capabilities Conference and Exhibition

"Dual Role of Robotic Technologies - Public and Private Sector"

Miami, FL

16 - 18 March 2010

Agenda

Wednesday, March 17, 2010

Keynote Speaker
- Mr. Chris Scolese, Associate NASA Administrator

Dual Use Combat Developers Panel:
- Brig Gen Dave Howe, Air Combat Command, A7
- Col Mark LaViolette, USMC, Capabilities and Acquisition Division (CAD), Joint Staff, J-8

Thursday, March 18, 2010

Joint Ground Robots Enterprise Overview
- Dr. Jim Overholt, Director, Joint Ground Robotics Enterprise

Dual Use Science & Technology Panel
- Mr. John Miller, Director, Army Research Laboratory
- Mr. George Solhan, Deputy Chief of Naval Research for Expeditionary Maneuver Warfare & Combating Terrorism; and Director, Marine Corps Science & Technology

Dual Purpose Industry Panel
- Mr. Ken Stratton, Senior Technical Steward, Caterpillar Corporation

Dual Use Material Developers Panel
- BGen Michael Brogan, Commander MARCORSYSCOM and Mr. Michael Asada, DPEO GCS
- CDR Aaron S. Peters, Deputy, Program Manager EOD

NDIA
National Defense Industrial Association

PROMOTING NATIONAL SECURITY SINCE 1919

► This year's conference will highlight robotic "dual-use" technologies originating from defense laboratories, NASA, the medical and automotive industries. In attendance will be leaders, designers and operators from a variety of robotic activities. This conference will provide a great opportunity to learn hard lessons the easy way!

2010 GROUND ROBOTICS CAPABILITIES CONFERENCE & EXHIBITION

Dual Role of Robotic Technologies- Public and Private Sector

MARCH 16-18 2010

WWW.NDIA.ORG/MEETINGS/0380

DORAL ► MIAMI, FL

EVENT #0380

WHY ATTEND?

See first hand the innovative ideas springing up and hear directly from leaders in all communities on what capability gaps they feel still exist. It is an opportunity to capture new ideas, techniques and procedures.

TUESDAY, MARCH 16, 2010

4:00 pm-6:30 pm REGISTRATION OPENS

5:00 pm-6:30 pm NETWORKING RECEPTION

QinetiQ North America

WEDNESDAY, MARCH 17, 2010

7:00 am-8:00 am REGISTRATION AND CONTINENTAL BREAKFAST - IN EXHIBIT HALL

8:00 am WELCOME
- ▶MG Barry Bates, USA (Ret), VP, Operations NDIA
- ▶Jose Gonzalez, OUSD (Acquisition, Technology & Logistics), Deputy Director, Land Warfare & Munitions

8:05 am ADMINISTRATIVE COMMENTS
- ▶VADM Joe Dyer, USN, (Ret) & Robotics Division Chair

8:10 am-9:00 am KEYNOTE
- ▶Hon. Charles Bolden, NASA Administrator

9:00 am-10:00 am DUAL USE COMBAT DEVELOPERS PANEL
Chair: Hon. Charles Bolden, NASA Administrator
- ▶TBD, Navy
- ▶Mr. Don Sando, Director, Capabilities & Integration of Maneuver Center of Excellence, US Army Training & Doctrine Command
- ▶BGen Lee Miller, Director, Capabilites Development Directorate, Marine Corps Combat Development Command
- ▶Brig Gen David Howe, Director, Installations & Missions Support, Air Combat Command
- ▶BGen Glenn Walters, Deputy Director for Resources & Acquisition, J-8

10:00 am-10:30 am BREAK IN EXHIBIT HALL

10:30 am-11:00 am WARFIGHTER PRESENTATION
- ▶MG Keith Walker, Director, Future Force Directorate, US Army Training & Doctorine Command

11:00 am-12:00 pm WARFIGHTER PANEL
Chair: LtCol David Thompson, PM, Robotics Systems Joint Program Office
- ▶"Soldiers from the Future Force Directorate", Ft. Bliss, TX

12:00 pm-12:45 pm JOINT GROUND ROBOTICS ENTERPRISE REVIEW
- ▶Dr. Jim Overholt, Director, Joint Ground Robotics Enterprise

12:45 pm-2:00 pm LUNCH & AWARDS PRESENTATIONS

ROBOT ROUND UP ON THE GREEN! - LOCATED IN EXHIBIT HALL

2:00 pm-3:00 pm COMPETITIONS - BATTLE-PROVEN ROBOTS

ROBOT ROUND UP ON THE GREEN! -CONT.

3:15 pm-4:00 pm	DEMONSTRATIONS - ADVANCED TECHNOLOGY ROBOTS
4:15 pm-5:00 pm	COMPETITION AWARDS
5:00 pm-6:30 pm	RECEPTION IN EXHIBIT HALL Sponsored by: iRobot

THURSDAY, MARCH 18, 2010

8:00 am	OPENING REMARKS ▶VADM Joe Dyer, USN, (Ret) & Robotics Division Chair
8:05 am-8:35 am	GUEST SPEAKER ▶TBD
8:35 am-9:35 am	DUAL USE SCIENCE & TECHNOLOGY PANEL ▶Mr. Wendell Banks, Director, Plans & Program, Air Force Research Laboratory ▶Dr. Grace Bochenek, Director, Tank Automotive Research, Development, & Engineering Center, US Army Training & Doctrine Command ▶Mr. John Miller, Director, Army Research Laboratory ▶Mr. George Solhan, Deputy Chief of Naval Research for Expeditionary Maneuver Warfare & Combating Terrorism; and Director, Marine Corps Science & Technology ▶TBD, Navy
9:35 am-10:05 am	BREAK IN EXHIBIT HALL
10:05 am-11:05 am	DUAL PURPOSE INDUSTRY PANEL ▶Dr. J.D. Crouch II, President, Technology Solutions Group, QinetiQ North America ▶Dr. Hugh Herr, PhD, MIT Media Lab ▶Mr. Colin Angle, Co- Founder, Chairman & CEO, iRobot Corp. ▶Dr. Barbara Lindauer, Business Development, General Dynamics Robotic Systems ▶Ken Stratton, Sr. Technical Steward, Caterpillar Corp.
11:05 am-11:35 am	KEYNOTE TBD
11:35 am-12:35 pm	DUAL USE MATERIAL DEVELOPERS PANEL ▶Mr. Victor Gavin, Executive Director, Program Executive Office, Littoral & Mine Warfare ▶BGen Michael Brogan, Commander, Marine Corps Systems Command ▶BG David Ogg, Program Executive Officer, Ground Combat Systems
12:35 pm-1:00 pm	WRAP-UP ▶Dr. Jim Overholt, Director, Joint Ground Robotics Enterprise
1:00 pm	BOX LUNCH-PICK UP IN EXHIBIT HALL
1:30 pm	CONFERENCE ADJOURNED

WHO SHOULD ATTEND?

OPERATIONAL -
Tactical Users
Requirements Generators
Concepts Developers
Trainers
Logisticians

TECHNOLOGY-
Government Laboratories, industry and academia focused on unmanned ground systems.

Developers of peripheral technologies (power, controllers, manipulators, tools, sensors, miniaturization, etc.).

Those interested in transfering military robotic technology to commercial markets.

SPONSORSHIP OPPORTUNITIES:

Networking Reception Sponsor (available to 2 sponsors):
This is your organization's chance to be the leader of the pack and sponsor the very first event Tuesday evening. This elite sponsorship offers a distinct opportunity for your company to receive maximum exposure to hundreds of attendees by giving you:
Investment: SOLD to QinetiQ North America

Grand Reception (available to 2 sponsors):
Nothing completes a conference more than networking during a reception you sponsored! With your company logo on cocktail napkins, in the onsite agenda and more, attendees are drawn to your booth to socialize and see what you have to offer on Wednesday evening. Be sure to let the attendees know that you appreciate them and let the drinks be on you!
Investment: SOLD to iRobot

Networking Breakfast Sponsor (available to 2 sponsors):
This early morning breakfast is slotted for 7:00 am Wednesday and Thursday morning of the conference and designed to have a bright look at the future and reflect on the trends to come all over bagels and coffee.
Investment: $4,000 each (Title Sponsor $7,000)

Lunch Sponsorship (available to 2 sponsors):
This is a great opportunity to highlight your company's name in the middle of the day to the attendees while they eat.
Benefits include:
Investment: $5,000 each (Title Sponsor $8,000)

Elite Padfolio/Tote Bag Sponsorship (limited to one sponsor):
This elite padfolio or tote bag is a very popular, reusable item which will be handed out to each attendee as they pick up their badge onsite. These padfolios or tote bags are carried throughout the entire event, and with your company's literature insert inside and logo on the front, gives you a great opportunity to advertise. (You can substitute the padfolio for a tote bag for the same cost.)
Investment: $5,000

Coffee Break Sponsorship (available to 4 sponsors):
Good conferences offer fresh coffee, and attendees always appreciate a good cup of brew for that early, mid-morning or afternoon break. Take advantage of this opportunity and become the Coffee Break Sponsor in the exhibit hall offered am or pm on Wednesday and/or am or pm on Thursday.
Investment: $4,000 each (Title Sponsor $10,000)

Lanyards (limited to one sponsor):
What better way to market your company everyday of the conference than to have your logo printed on lanyards which will hold name badges for the attendees and exhibitors.
Investment: $4,000

SPONSORSHIP OPPORTUNITIES CONT.:

Literature Insert Sponsors (available to three sponsors): Inserting one page flyers into all the attendee padfolios (if available) or handed out with the on-site agenda is a great way to promote a new product or service. Company provides the promotional flyer materials.
Investment: $1,000 (If NDIA prints the insert, investment increases to $1,500)

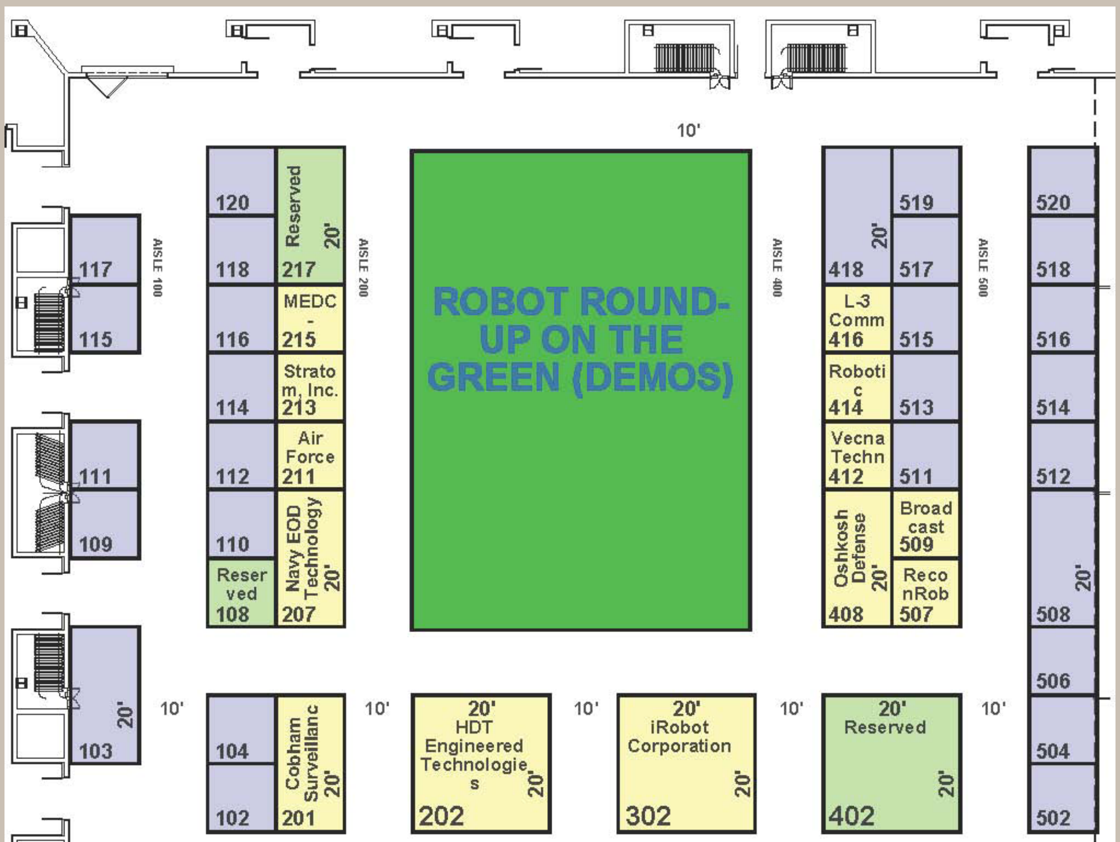
NEW! Banner Sponsorships (Exhibitors Only): How can you make it easier for attendees to visit your booth? Become a banner sponsor and advertise your booth number via the Robot Round-up on the Green! Banners are located inside the exhibit hall and placed on the inside rail of the Robot Round-up on the Green. The round-up offers a great gathering place for a quick on-site meeting, taking a rest from walking or sitting on the bleachers for a few hours watching the robots demonstrate their capabilities. The round-up is also centrally located in the exhibit hall so as attendees walk by, your logo and booth number stand out. If you prefer, banners can also be hung from the ceiling. Banners can be one sided or two sided and can be provided by the sponsoring company or produced by NDIA. *Note, only ceiling hung banners can be double-sided. Investment prices are listed below if NDIA produces the banner.
A. Single sided 4' x 10' = 40' sq. ft. banner Total $2,500.
B. Double sided 4' x 10' = 40' sq. ft. banner Total $2,700.
C. Single sided 4' x 12' = 48' sq. ft. banner Total $2,700.
D. Double sided 4' x 12' = 48' sq. ft. banner Total $2,900.
Total $1,500 for single banners and $2,000 for double banners if the company produces the banner and delivers it to the exhibit hall. All companies who are producing their own banners need to get it pre-approved before the event, with a graphic sent to NDIA.
NOTE: All sponsors are responsible for the shipping of their banners back to their offices after the banners have been taken down at the end of the event. Shipping is not included in these figures above.

Create Your Own Opportunity!
Many of the NDIA events offer category exclusive sponsorships to fit your budget. By enhancing your brand with a sponsorship at our events you'll build a stronger perception from the audience and stand out from the crowd. NDIA is open to custom sponsorship ideas.

*** For more information on what the available Sponsorships fully include, please contact Alden Davidson, CEM, Associate Director, at (703)-247-2582 or email: adavidson@ndia.org or Laura Hoover, Providing Sponsorship Service for NDIA, at (804)-437-3773 or email: laura_hoover@hotmail.org.**

EXHIBITOR INFORMATION:

COMPANY NAME	BOOTH #
AIR FORCE RESEARCH LAB	211
BROADCAST MICROWAVE SERVICES	509
COBHAM SURVEILLANCE, DTC PRODUCTS	201
ELBIT SYSTEMS OF AMERICA	217
QINETIQ NORTH AMERICA	402
HDT ENGINEERED TECHNOLOGIES	202
IROBOT CORPORATION	302
L-3 COMMUNICATION SYSTEMS WEST	416
MEDC - DEFENSE CONTRACT COORDINATION CENTER	215
NAVY EOD TECHNOLOGY DIVISION	207
OSHKOSH DEFENSE	408
RE2, INC.	108
RECONROBOTICS INC	507
ROBOTIC RESEARCH, LLC	414
STRATOM, INC.	213
TORC TECHNOLOGIES	104
VECNA TECHNOLOGIES	412



WHY EXHIBIT?

This conference brings together government laboratories, industry and academia focused on unmanned ground systems, peripheral technologies, concept developers, logisticians and more for the advancement of the Ground Robotics industry. The U.S. Government is spending $1.7 billion on ground-based military robots from now to 2012 and 1/3 of ground combat vehicles will be unmanned by 2015.

COST TO EXHIBIT:

Government, Academia and NDIA Corporate Member Rate*: $24.00/ sq.ft
(Note: Your Corporate Member dues must be current to receive the member rate).

Non-Corporate Member Rate: $29.00/sq.ft.

Booths are sold in 100 sq.ft. increments. NDIA does not charge for corner or island fees. No "end cap" booths are permitted. Booth furnishings are not included and floor is already carpeted.

MEMBERSHIP DISCOUNT:

$500.00 savings per 10x10 booth
To qualify for the member discount, your company has to join NDIA as a Corporate Member. For more information on joining or contact Zoila Martinez at 703-247-2565.

EXHIBIT RATE INCLUDES:

~Networking social function in the exhibit hall
~All scheduled meal events including lunches, breakfasts, etc.
~Two complimentary conference registrations for exhibit personnel, per 10' x 10' (100 sq. ft.) All additional exhibit personnel registrations must register on the conference page at www.ndia.org/meetings/0380
~24-hour security
~Fabric back and side walls and 7" x 44" ID sign

REGISTRATION INFORMATION:

Registration Fees

	Early (Before 2/11/10)	Regular (2/11/10-2/25/10)	Late (After 2/25/10)
Government/ Academia/ Allied	☐ $550	☐ $605	☐ $680
Industry NDIA Member	☐ $690	☐ $760	☐ $855
*Industry Non-NDIA Member	☐ $765	☐ $840	☐ $945

ONLINE:

Our preferred method of registration is online.
Visit http://www.ndia.org/meetings/0380 to register today.

FAX:

Register via fax by completing the below Registration Form and faxing it to (703) 522-1885. Please do not fax any registrations after March 4, 2010.

MAIL:

Registration forms may be mailed to:
NDIA, Event #0380, 2111 Wilson Blvd., Suite 400, Arlington, VA 22201.
Please do not mail any registrations after March 4, 2010.
Registrations will not be taken over the phone.

Payment must be made at the time of registration.

CANCELLATION POLICY

Cancellations before 2/25/10 receive refund minus a $75 cancelation fee. No refunds for cancellations received on/after 2/25/10. Cancellations must be made in writing. **Substitutions welcome in lieu of cancellation**s. Please e-mail your cancellations or substitutions to Mary Katherine Saladino via email: msaladino@ndia.org.

GENERAL CONFERENCE INFORMATION:

*HOTEL INFORMATION

A limited number of rooms have been reserved at the Doral, Miami, FL. To make a reservation, call 1 (800) 228-9290 and |ask for the "NDIA Room Block" The cut-off date for accepting reservation into this block is February 19, 2010, but rooms may sell out before then.

ATTENDEE ROSTER

An attendance roster will be distributed at the conference. Your registration form and payment must be received March 8, 2010 to be included in the roster. An updated roster will NOT be printed after the conference.

INQUIRIES

For more information, contact Mary Katherine Saladino, Meeting Planner, NDIA, at 703-247-2540 or via e-mail at msaladino@ndia.org and refer to the Ground Robotics Capabilities Conference.

CONFERENCE ATTIRE

The appropriate attire for this conference is business attire or Military Duty uniform.

SPECIAL NEEDS

NDIA supports the Americans with Disabilities Act of 1990. Attendees with Special Needs should contact Mary Katherine Saladino by March 4, 2010 via email: msaladino@ndia.org and refer to the Ground Robotics Capabilities Conference.

GROUND ROBOTICS CAPABILITIES CONFERENCE AND EXHIBITION

Miami, FL • March 16-18, 2010 • Event # 0380

National Defense Industrial Association
2111 Wilson Boulevard, Suite 400
Arlington, VA 22201-3061
(703) 522-1820 • (703) 522-1885 fax
www.ndia.org

NDIA National Defense Industrial Association

3 Ways to sign up:
1. Online with a credit card at www.ndia.org
2. By fax with a credit card — Fax: 703-522-1885
3. By mail with a check or credit card * Faxed/Mail Registration Forms will recieve an email confirmation in about 7-10 business days.

☐ Address change needed

NDIA Master ID/Membership # ____________________ Social Security # ____________________
(if known—hint: on mailing label above your name) *(last 4 digits – optional)*

Prefix ____________________
(e.g. RADM, COL, Mr., Ms., Dr., etc.)

Name First ____________________ MI ______ Last ____________________

Military Affiliation ____________________ Nickname ____________________
(e.g. USMC, USA (Ret.) etc.) *(for Meeting Badges)*

Title ____________________

Organization ____________________

Street Address ____________________

Address *(Suite, PO Box, Mail Stop, Building, etc.)* ____________________

City ____________________ State ______ Zip ______ Country ____________________

Phone ____________________ ext. ______ Fax ____________________

E-Mail ____________________

Signature* ____________________ Date ____________________

Preferred way to receive information

Conference information ☐ address above ☐ Alternate *(print address below)* ☐ E-mail

Subscriptions ☐ address above ☐ Alternate *(print address below)*

Alternate Street Address ____________________

Alternate Address *(Suite, PO Box, Mail Stop, Building, etc.)* ____________________

City ____________________ State ______ Zip ______ Country ____________________

** By your signature above you consent to receive communications sent by or on behalf of NDIA, its Chapters, Divisions and affiliates (NTSA, AFEI, PSA, WID) via regular mail, e-mail, telephone, or fax. NDIA, its Chapters, Divisions and affiliates do not sell data to vendors or other companies.*

By completing the following, you help us understand who is attending our meetings.

Primary Occupational Classification. *Check ONE.*

- ☐A. Defense Business/Industry
- ☐B. R&D/Laboratories
- ☐ C. Army
- ☐ D. Navy
- ☐ E. Air Force
- ☐ F. Marine Corps
- ☐ G. Coast Guard
- ☐ H. DOD/MOD Civilian
- ☐ I. Gov't Civilian (Non-DOD/ MOD)
- ☐ J. Trade/Professional Assn.
- ☐ K. Educator/Academia
- ☐ L. Professional Services
- ☐ M. Non-Defense Business
- ☐ N. Other

Current Job/Title/Position. *Check ONE.*

- ☐ A. Senior Executive
- ☐ B. Executive
- ☐ C. Manager
- ☐ D. Engineer/Scientist
- ☐ E. Professor/Instructor/Librarian
- ☐ F. Ambassador/Attaché
- ☐ G. Legislator/Legislative Aide
- ☐ H. General/Admiral
- ☐ I. Colonel/Navy Captain
- ☐ J. Lieutenant Colonel/ Commander/Major/ Lieutenant Commander
- ☐ K. Captain/Lieutenant/Ensign
- ☐ L. Enlisted Military
- ☐ O. Other

Year of birth ____________________
(Optional)

Registration Fees

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*Includes a free three-year NDIA membership and *National Defense* magazine for Military and Government employees (first time members only).

☐ No do not sign me up for the membership.

Payment Options

- ☐ Check *(payable to NDIA)*
- ☐ Cash
- ☐ Government PO/Training Form # ____________________
- ☐ VISA
- ☐ MasterCard
- ☐ American Express
- ☐ Diners Club

If paying by credit card, you may return by fax to (703) 522-1885.

Credit Card Number

Exp. date ☐☐ / ☐☐

Signature ____________________ Date ____________________

Questions? Contact Mary Katherine Saladino, Meeting Planner
(703) 247-2540 e-mail: msaladino@ndia.org

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Arlington, VA 22201

Fax to: (703) 522-1885

Dual Use
Material Developers Panel

BGen Michael Brogan, Commander MARCORSYSCOM
Mr. Michael Asada, DPEO GCS
18 March 2010

UNCLASSIFIED: Dist. A - Approved for public release

Evolution of Ground Robotics in War

2004
162 systems
- No single vendor could produce 162
- 5 vendors, multiple configurations
- Joint effort, EOD focused

2005
1800 systems
- Robot's proven ability to save lives
- Expansion beyond EOD mission (Countermine, Security)
- MOAs w/ AMC and REF

2006
4000 systems
- Engineers and Infantry
- Route clearance, Explosive detection & Weaponization development

2007
5000 systems
- Special Forces robot applications assessed
- Route clearance, Explosive detection & Weaponization on battlefield

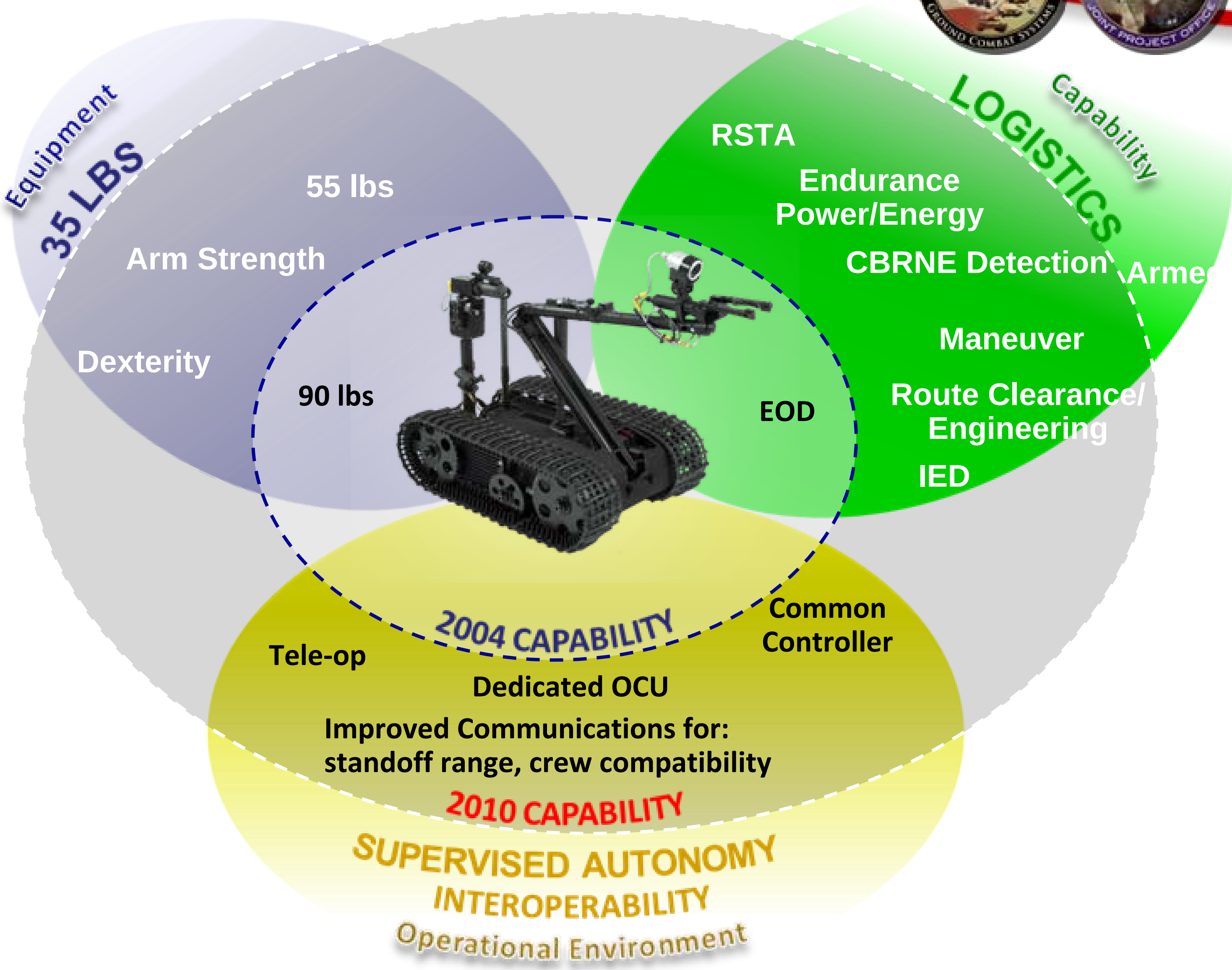
2008
6000 systems
- Maneuver elements
- Range extension
- CBRNE detection
- Persistent surveillance
- RC HMMWV
- More capable payloads

2009
7000 systems
- Smaller platforms
- Enhanced battery life
- Enhanced commonality
- Remote deploy
- More capable payloads

Future
- Interop
- 'Plug and play' capabilities
- Limited autonomy
- Weaponization
- Increased agility & dexterity

Sustainment, Modernization, Interoperability and Modularity

Robotic Modernization



Enhancing Warfighter Capabilities

Joint Robotic Repair and Fielding JRRF

BACKGROUND

- The Joint Robotics Repair and Fielding (JRRF) Activity established in mid 2004.
- Provides maintenance, supply and training for all Joint Service Non Standard Equipment Robotics.

MISSION

- Provide in-Theater Support for Joint Service Theater Provided Equipment (TPE) Ground Robots.
- Single "one-stop-shop" for fielding, sustainment, training, assessment and total asset accountability for all robotic systems in theater.

SUPPORT

- Current JRRF operations
- Embedded repair teams to remote units
- Pre-deployment support capability at Combined Training Centers
- 13 JRRF detachments world wide

Training, Sustainment, Assessment, and Accountability

RS JPO Systems

- Based primarily on ONS / JUONS requirements
- Commercial-off-the-shelf / modified-off-the-shelf
  - Commercial radios
  - Commercial components
  - Non MIL-STD
  - Obsolescence
  - Configuration control
- Procured under ‘Rapid Acquisition’
  - REF and JIEDDO lead
- Provide immediate capabilities
  - 70 to 80% solutions

Dual Use Technologies

- Obstacle detection & avoidance
  - Military: pedestrians, terrain and man-made obstacles
  - Civilian: automobile safety technologies – active cruise control
- Autonomous navigation
  - Military: resupply, dynamic path planning
  - Civilian: automobile safety technologies – active cruise control
- Increased communication range
  - Military: increased standoff
  - Civilian: command post (DHS/1st Responders), wireless networks
- Multi robot control
  - Military: one controller/many robots, manning levels
  - Civilian: warehousing
- Interoperability
  - Military: agile mission response
  - Civilian: USB ports, iPhone
- Improved battery technologies / fuel cells
  - Military: longer life, reduced soldier load
  - Civilian: fossil fuel dependence

AF Engineer Robotic Requirements

BGen Dave Howe
ACC/A7
17 Mar 10

This Briefing is:
UNCLASSIFIED

Overview

- Kudos to our Airmen...they're "all in" the current fight
- AF EOD robotics program
- New AF Emergency Management robotics initiative
- Number 1 AF Priority for robotics...airfield damage repair
- Closing remarks/summary

Our Airmen are (still) Engaged in the Current Fight

- **AF transporters, contracting specialists, services teams and security forces are all on the ground supporting the current war effort**
  - **Convoying critical commodities, ensuring our troops are fed and routes and bases are secured**

- **Our Engineers are supporting Joint tasks...RED HORSE; building roads, repairing bridges and critical infrastructure...EOD; defeating the IED threat; working to deny the enemy resources to create IEDs...finding and destroying weapons caches, working as weapons intelligence team members to use forensics to identify bomb makers**

Airmen are members of the Joint team...”we’re all in”

HD-1/HD-1 AF Variant

Requirement

Requirement driven by feedback and lessons learned from deployed EOD techs. Procure and field a robot with the capability of increased operating distance, increased handling capability and ability to operate in current ECM environment.

Additional requirements include: ability to deliver current fielded specialized EOD tools (PAN, J-ROD, Powerhawk) as well as new EOD tool under development, e.g., Multi-shot IED Disrupter System (MIDS).

HD-1 (top pixs); HD-1 AF Variant (bottom pixs)

HD-1/HD-1 AF Variant Capabilities

Weighs approximately 220 pounds; <u>not a MTRS</u>. HD-1 robot initially fielded FY06/FY07 time-frame; improvements driven by operators. HD-1 AF Variant incorporates emerging radio technology; extends stand-off range; increased handling capability; extended operating time (enhanced battery); ability to reach below ground, rotating torso, presets, and ability to operate in electronic countermeasures (ECM) environment. Initial operator evaluation conducted Sep 09…final production configuration expected to be available mid-2010.

HD-1/HD-1 AF Variant Posturing

All HD-1 robots will be upgraded in FY2010/2011.

Planned posture: HD-1 AF Variant at each unit as base support robot (55) and postured on UTC 4F9X1 (88).

Expanding the use of Robotics (New AF Initiative)

- **The Emergency Management career field, in conjunction with other CE AFSs, is pursuing an initiative to integrate CBRN/TIC/TIM detection sensors/collectors on Unmanned Ground Robotics as an installation capability to mitigate CBRN/TIC/TIM incidents in support of the Incident Commander during in-garrison/deployed incidents.**

- **The proposed approach is a common robotic platform with plug & play sensor/collector payloads to meet this requirement.**

Airfield Damage Repair
The Challenge

- **Must repair 90’x5000’ Minimum Operating Strip (MOS) plus access routes**
  - **Multiple small craters (8-10’ diameter)**
  - **Multiple UXO environment**
  - **Minimum time-on-repair**

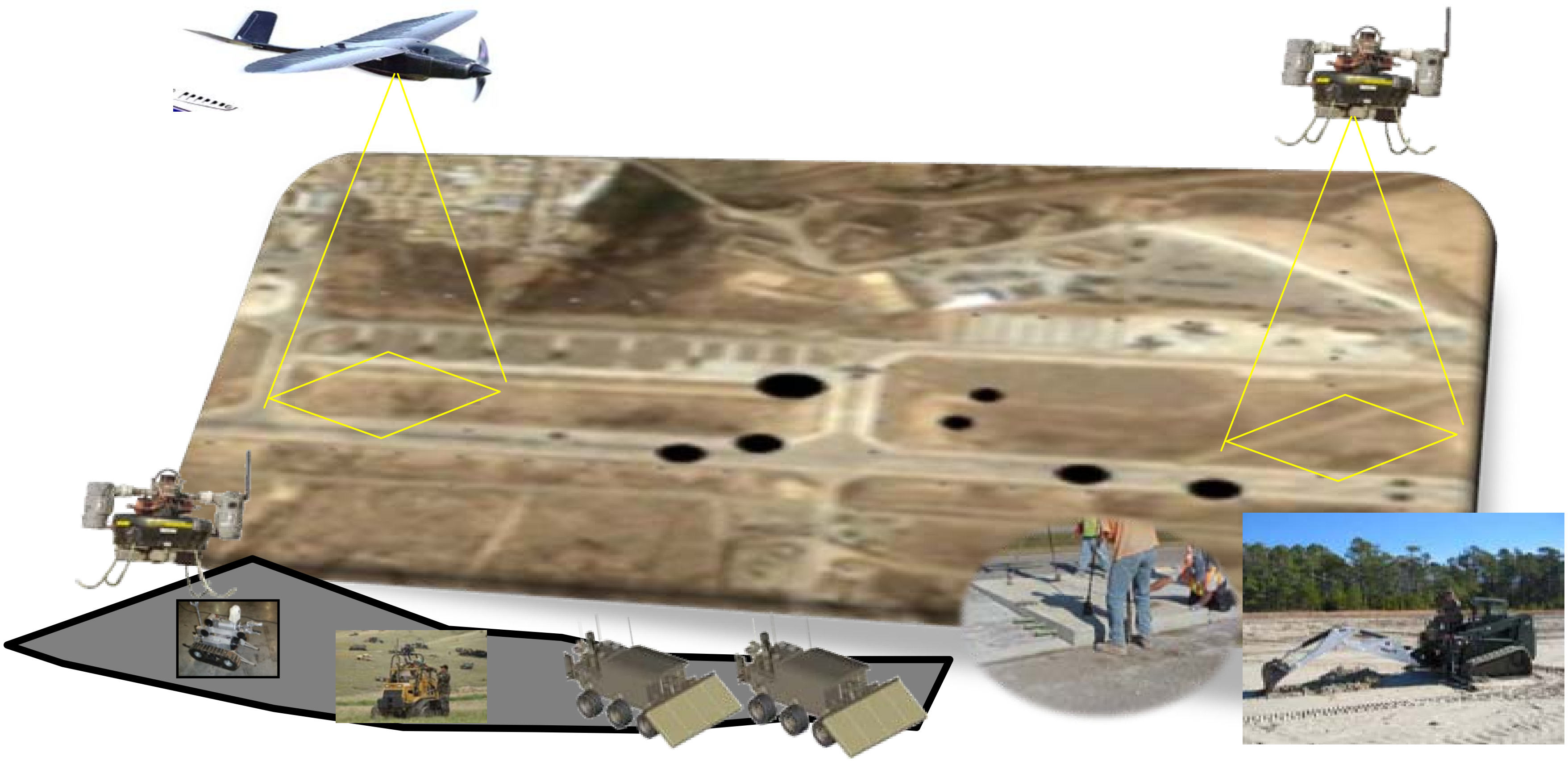
ADR Timeline/Desired Effects

- Focus on PACOM base recovery after attack scenario
- Provide a faster, graphically linked assessment of the airfield surface damage
  - Minimum Airfield Operating Surface (MAOS), runways, taxiways, and ramps
  - ID, measure and locate 100s of craters and locate UXOs
  - Identify candidate MAOS for each aircraft type within 0.5 hours
- Clear UXO/repair MAOS within 4-6 hours after attack and 3.5 hours after MAOS selection & UXO clearing
  - 100 small craters on runway & 100 on the MAOS
  - Support all assigned aircraft (fighters and heavies)
  - Improve quality/durability of repairs to extend lifespan of repairs

Airfield Damage Repair (ADR)

1) Assess Runway Damage & Unexploded Ordnance (UXO)

2) Determine Minimum Airfield Operating Surface



3) Identify, Render Safe, Remove Up to 100 UXOs on Access Surfaces

4) Repair Up to 100 Craters on Runway and Up to 100 on Access Surfaces

Return Runway to Operational State for All Aircraft/4-6 Hrs

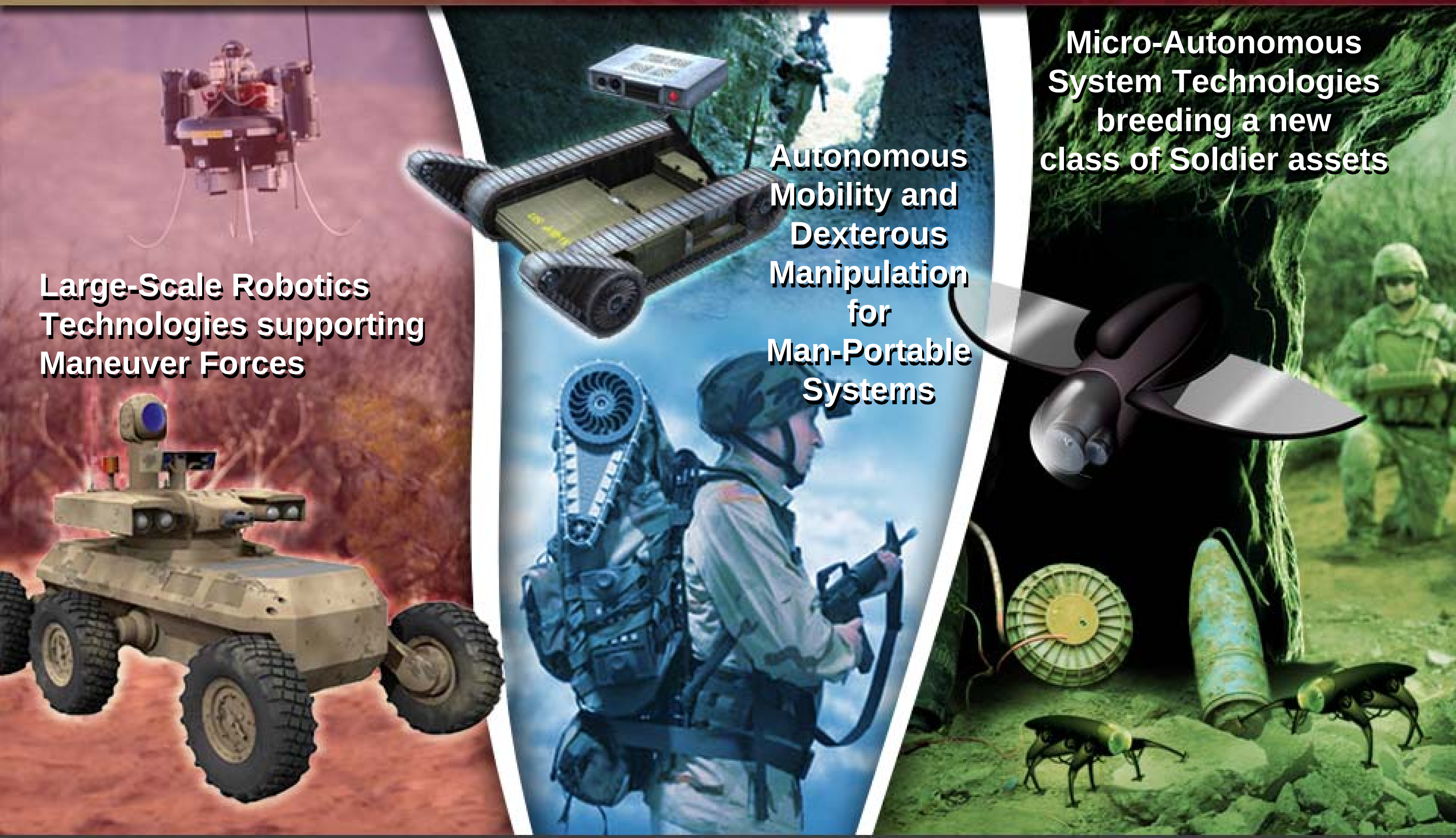
Closing Remarks/Summary

- Our Airmen continue to support the current fight
- We (AF) will continue to look for opportunities in other AF functions to expand the use of robotics to perform dangerous and dirty missions...robotics can be a force multiplier
- We must continue to leverage emerging robotic technologies and successes in industry and other government agencies as we plan for future contingencies

RDECOM

Autonomous System Technologies

ARL



Providing the Soldier with superior situational awareness

Robotics is a Dual-Use Technology

- *Military convoys*
- *Automated highways*

- *Reconnaissance in buildings*
- *Search & rescue in confined space*

- *Automating Rear-area logistics bases*
- *Flexible automation of factories*

- *EOD robots*
- *Robots for first responders*

ARL Robotics Research

Key technologies required to achieve our vision are:

Perception
- Sensing
- Terrain/object/Behavior understanding
- World Model

Intelligence
- Learn & Adapt
- Self-awareness
- Behavior
- Collaboration

HRI
- Shared awareness
- Trust & confidence
- Communication
- Operate w/I society
- Span of control

Manipulation
- Close coupling of sensing control & actuation
- Micro-mechanics
- Efficiency

Mobility
- Unconventional
- Three-dimensional
- Adaptive

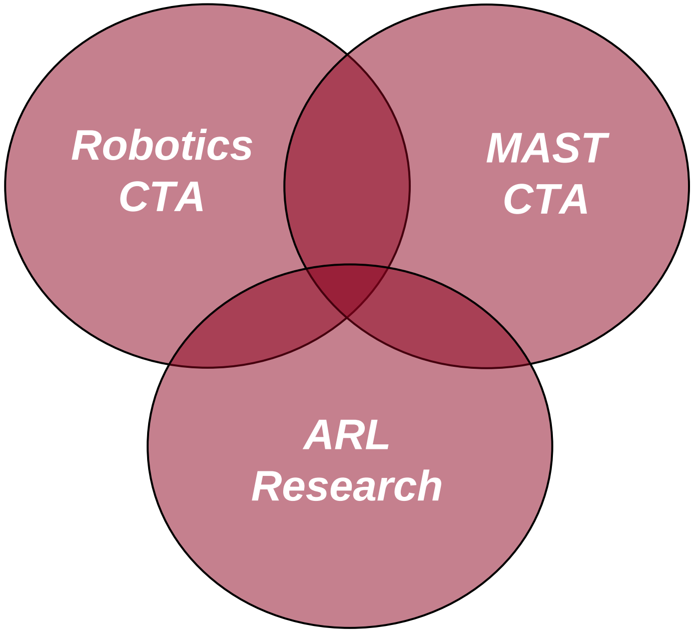
These will be supplemented by a number of supporting technologies with wider applicability

- Micro-electronics
- Power/Energy sources/storage/transmission, propulsion
- Image understanding/ATR
- Network Communication
- Materials & Structures
- Cognitive science, Psychology, Biology

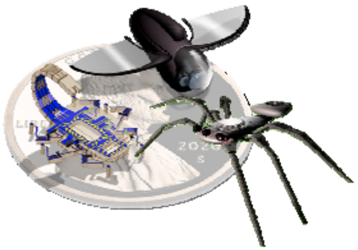
ARL Robotics Research

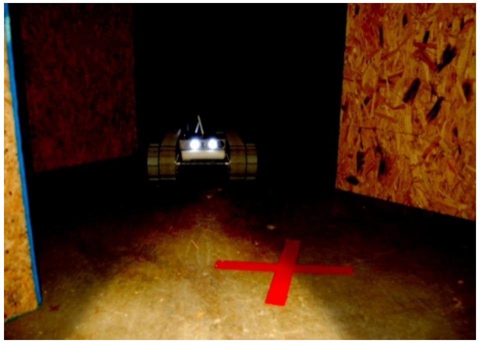
ARL sponsors wide-ranging collaborative research

- *Perception*
- *Intelligence*
- *Human-Robot Interaction*
- *Dexterous manipulation & unique mobility*



- *Microsystem mechanics*
- *Microelectronics*
- *Processing for autonomous operation*
- *Integration*
- *Power*





- *Army Research Office*
- *Computer & Information Sciences Dir.*
- *Human Research and Engineering Dir.*
- *Sensors and Electronic Device Dir.*
- *Vehicle Technology Dir.*

Joint Capabilities Development and Acquisition

2010 Ground Robotics Capabilities Conference & Exhibition

"Dual Use Combat Developers Panel"

Col Mark D. LaViolette, USMC
Capabilities and Acquisition Division (CAD)
Joint Staff, J-8

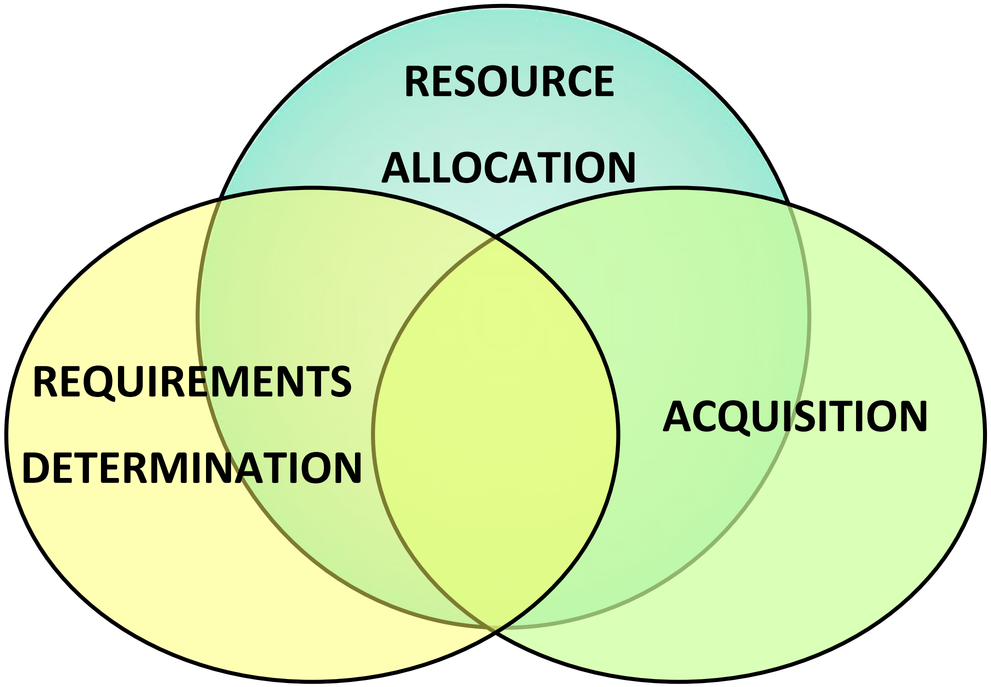
Bottom Line Up Front (BLUF)

- **Balancing Act:**
  - **Requirements, Resources, Acquisition**

- **Big "A" vs. Little "A"**
  - **Standard acquisition process slow but effective**
  - **Rapid Acquisition (e.g, JUONS) when appropriate**
  - **Other avenues: JCTD**

- **Resource Constrained Environment**

Joint Staff J8 Mission



- Requirement Determination - Planning, studies, analysis, assessments
- Resource Allocation - Programming/Budgeting
- Acquisition Execution - Deliver the required capabilities

Assist in Delivering the <u>Right Mix of Capabilities</u>
for the Joint Force Commanders

Challenge of Rapid Acquisition

- ★ Future Focused
- ★ Very Structured Process
- ★ Evolved Requirements
- ★ Analysis of Alternatives
- ★ Lengthy Development
- ★ High Visibility on Program
- ★ Large Investment

Big A

little a

- *Now* focused
- More *ad hoc* process
- Broad requirement
- Quick assessment of alternatives
- Limited development
- High visibility on results
- Limited investment
- Very Limited Feedback
- Transition to Program of Record

JUON Robots

- **10 Total CENTCOM JUONs**
  - **C-IED related**
  - **3 Active / 7 Fielded**
  - **Additional robots included in surge requirements**

- **Enhancements:**
  - **Deployment systems from vehicles**
  - **Detachable toolkits**
  - **Long-range antennas**
  - **Video capture**

New & Accelerated JCTD Process

6 MOS

12 MOS

18 MOS

24 MOS

Start

Legacy Selection Process
(includes JROC validation)

Legacy Execution Process

Start

Selection | **Execution** | **JROC**

Quarterly Program Review Boards

<u>Candidate Decision Board</u>

- Executable (Tech Readiness Lvl (TRL) 5-7)
- Addresses valid need
- OSD / DDR&E Chair
- JS / J8 DDR – CO-Chair

<u>Program Review Board:</u>

- Transfer to Program Of Record (POR); or
- Deliver residuals satisfying need; or
- Terminate
- Forward to JROC for validation

Start

Selection | Execution | JROC

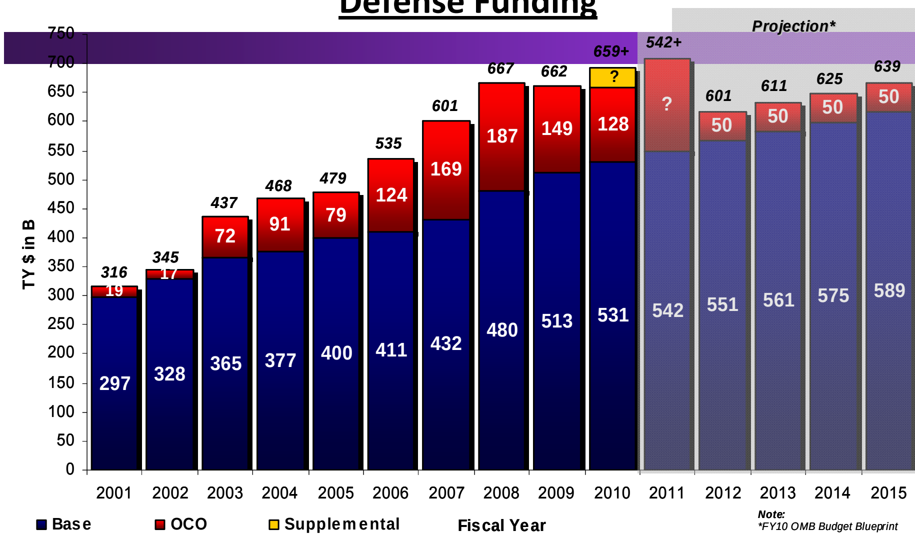
Start

Selection | Execution | JROC

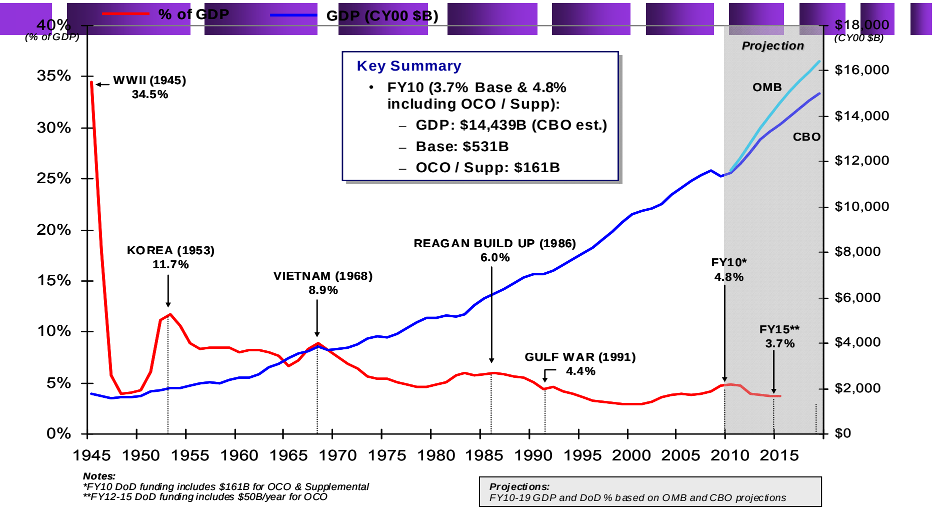
Joint Capability Technology Demonstrations (JCTD) Quarterly Starts / Transfer to POR as appropriate

Downward Budget Pressures

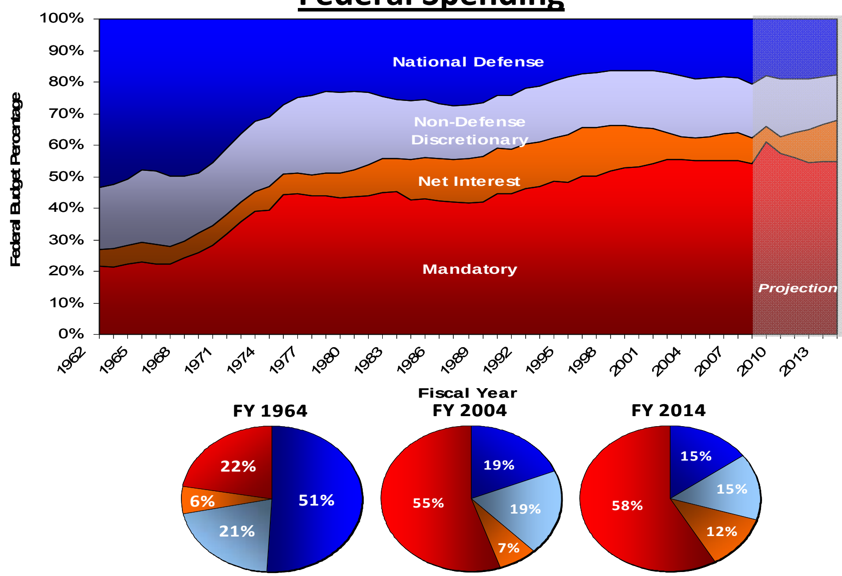
Defense Funding



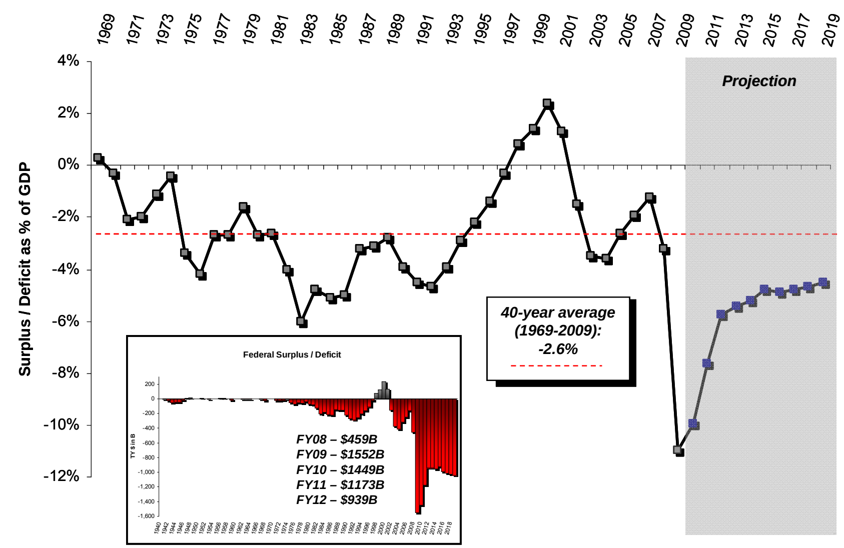
Defense as a Percentage of GDP



Federal Spending



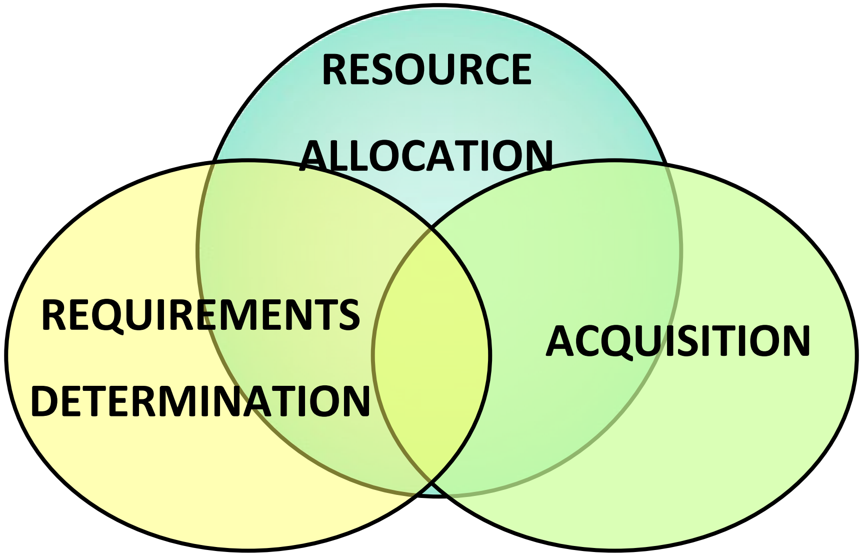
Federal Deficit/Surplus



Mounting deficits, interest payments & entitlement spending will result in downward pressure to defense budgets

Conclusion

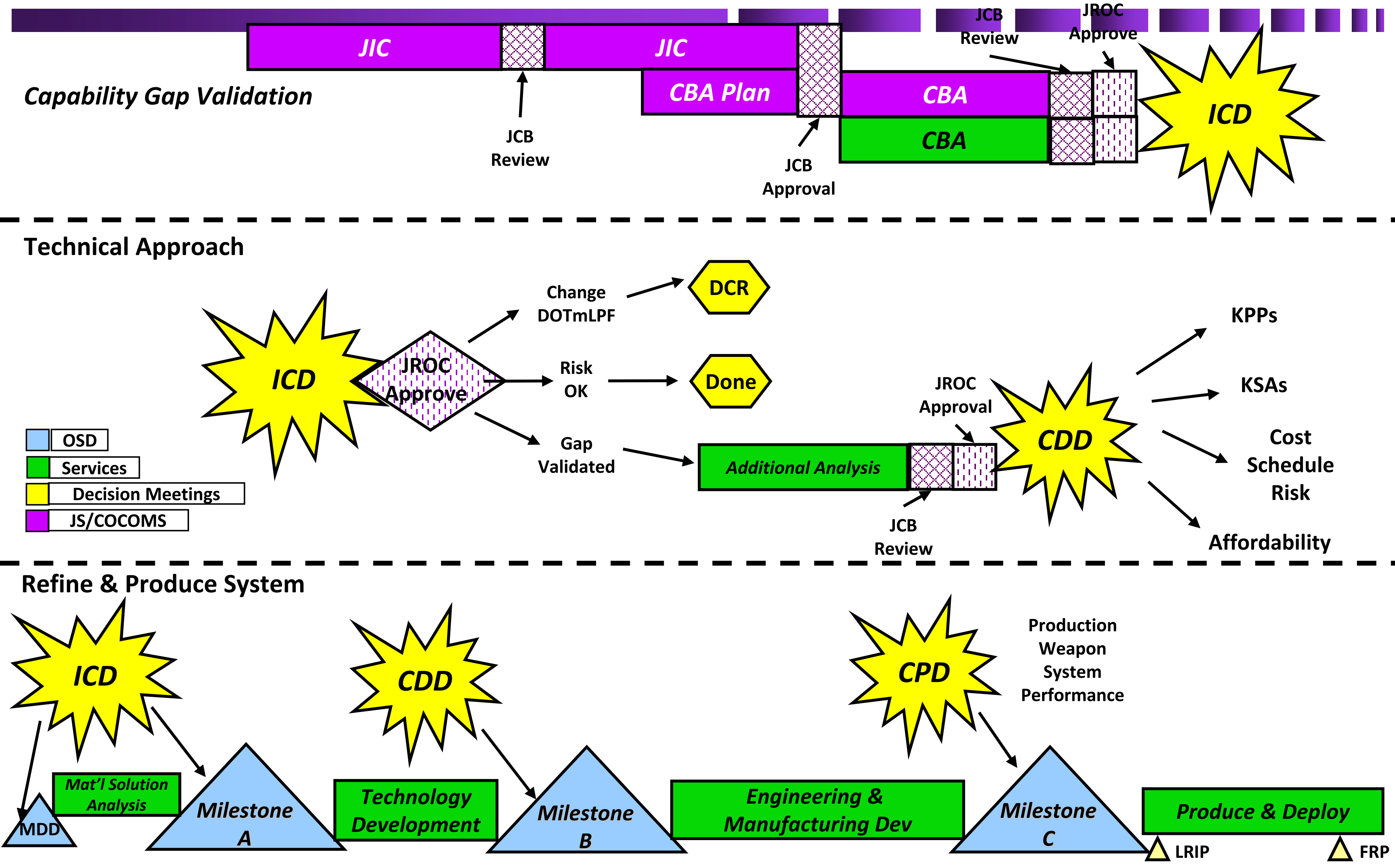
- J-8 committed to fielding right mix of Joint capabilities
- Use rapid acquisition process when appropriate
- Balancing priorities is critical




JOINT
CHIEFS OF STAFF

BACKUP SLIDES

Capability Based Assessment and Acquisition Processes



Rapid Fielding Framework

JUON Process Consists of Four Phases:

GENERATION PHASE → VETTING PHASE → EQUIPPING PHASE → OPERATIONS AND SUPPORT PHASE

GENERATION PHASE

Force Commander Identifies Urgent Need

Combatant Staff determines the most suitable process

COCOM CoS certifies and submits to Joint Staff (DJ-8 RMD)

VETTING PHASE

J-8 RMD Receives and verifies that JUON meets submission criteria

JUON is reviewed and routed

Solutions are identified

JRAC determines a resourcing Strategy.

EQUIPPING PHASE

Interim Sponsor creates a Simplified Acquisition Plan

Procures and deliver solution to the Warfighter

Provide Progress Reports On Performance, Cost, and Schedule

OPERATIONS AND SUPPORT PHASE

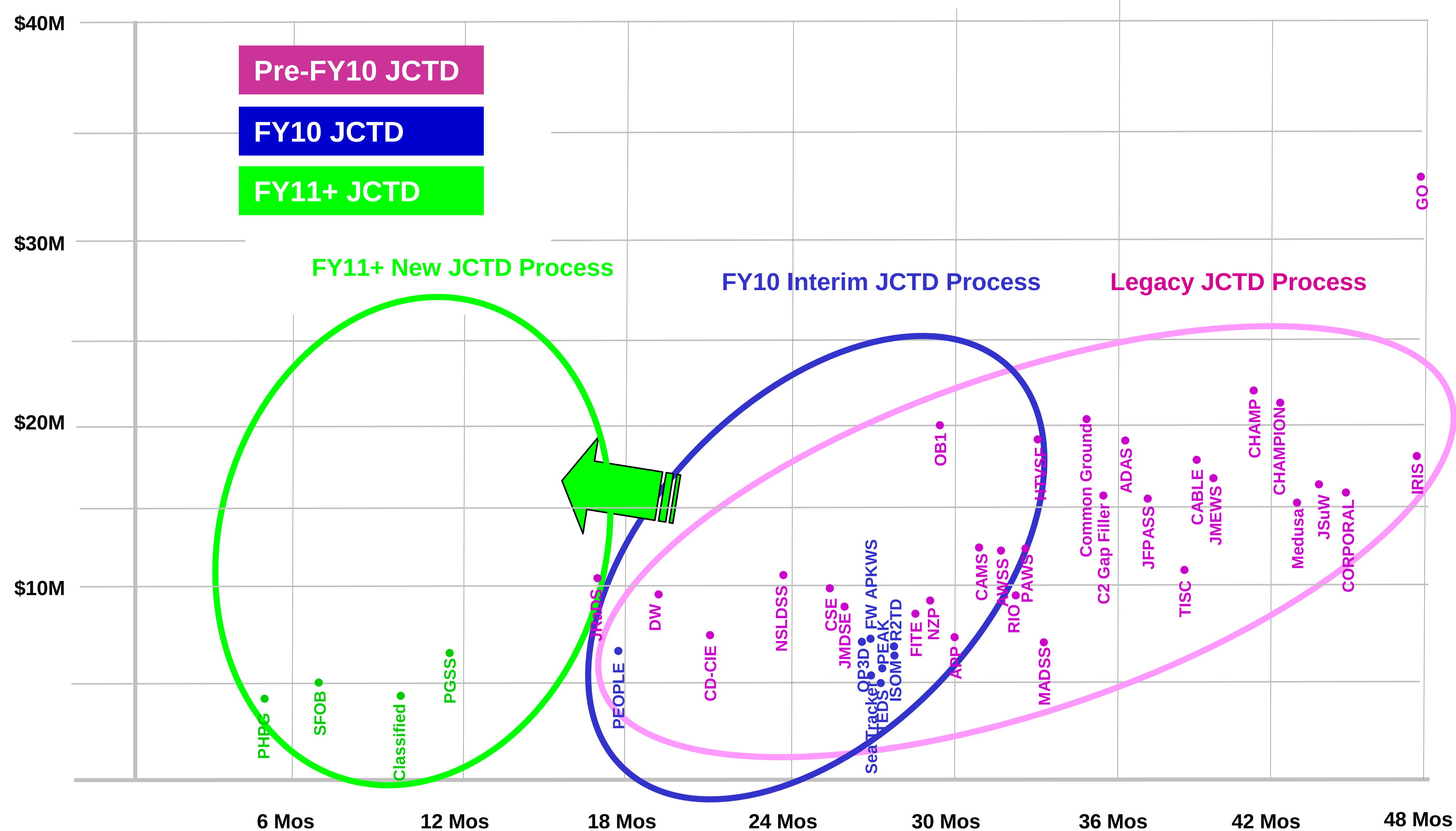
Interim Sponsor sustains solution and monitors performance for twenty- four months

Interim Sponsor, COCOM, and FCB prepare Capability Review to Address final disposition of fielded system.

SPEED IS LIFE

JCTD Historical Perspective

All JCTDs: 2006 – Present, DDR&E Funding



Joint Ground Robotics Enterprise
State of the Enterprise

Dr. Jim Overholt

17 March 2010

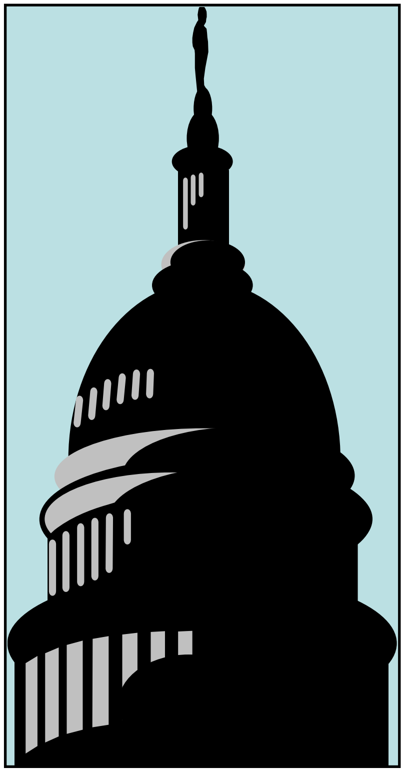
Agenda

- Congressional Language
- JGRE Overview and Organizational Structure
- JGRE Success Stories
- Robotics Range Clearance Competition (R2C2)

Congressional Language

CONGRESSIONAL DIRECTION

Department of Defense Appropriation Bill, 1990



“.....The Committee reluctantly concludes that the only way to produce a more focused and cost-effective robotics program is to delete funds for all the separate projects and consolidate them under <u>OSD policy and program direction</u> .....

.....The Committee also is concerned that many of the robotics programs are proceeding without definite requirements from those organizations which would employ such capabilities in combat.....

.....The Committee expects that OSD will decide both the funding and technology priorities for these efforts....”

Agenda

- Congressional Language
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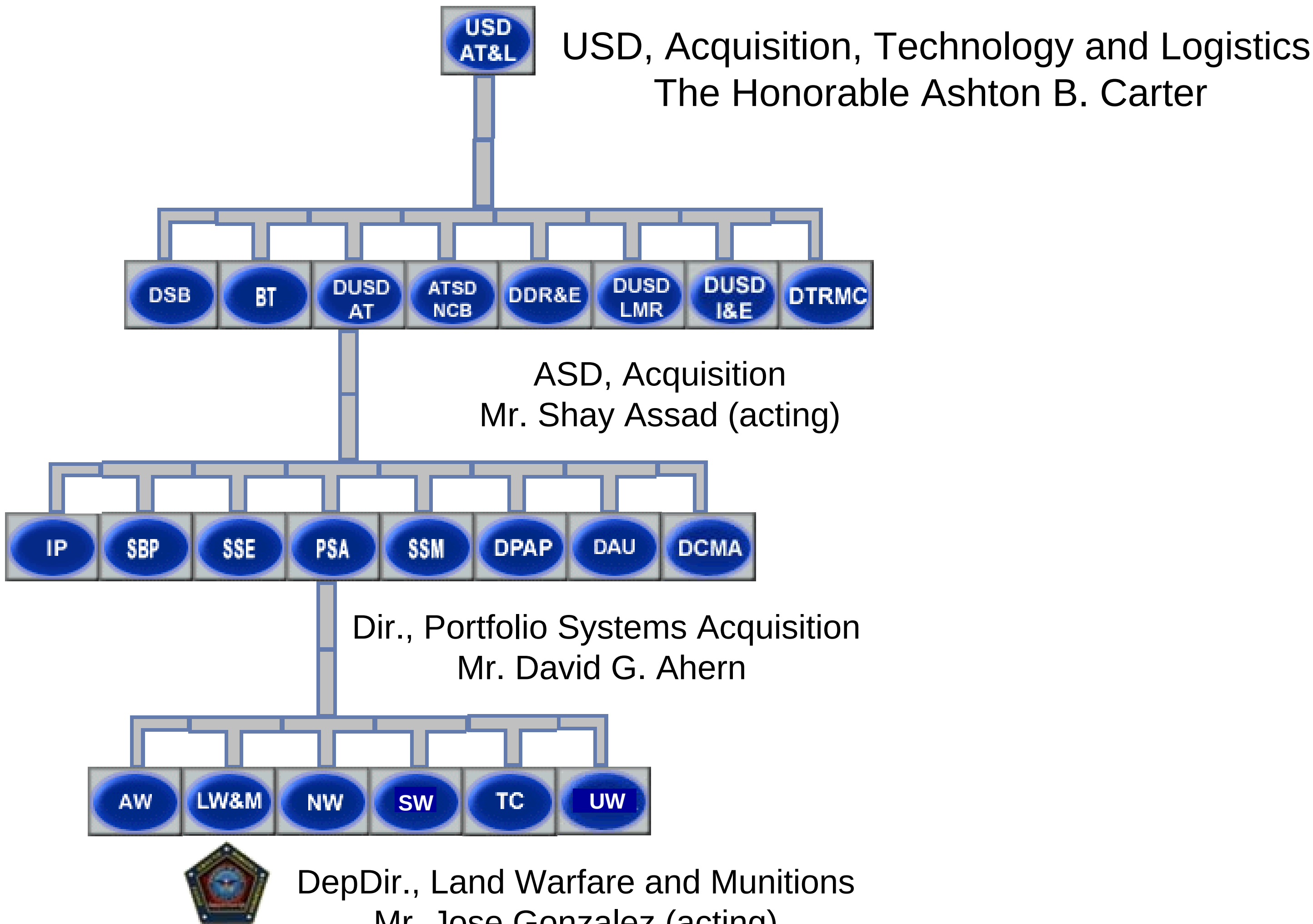
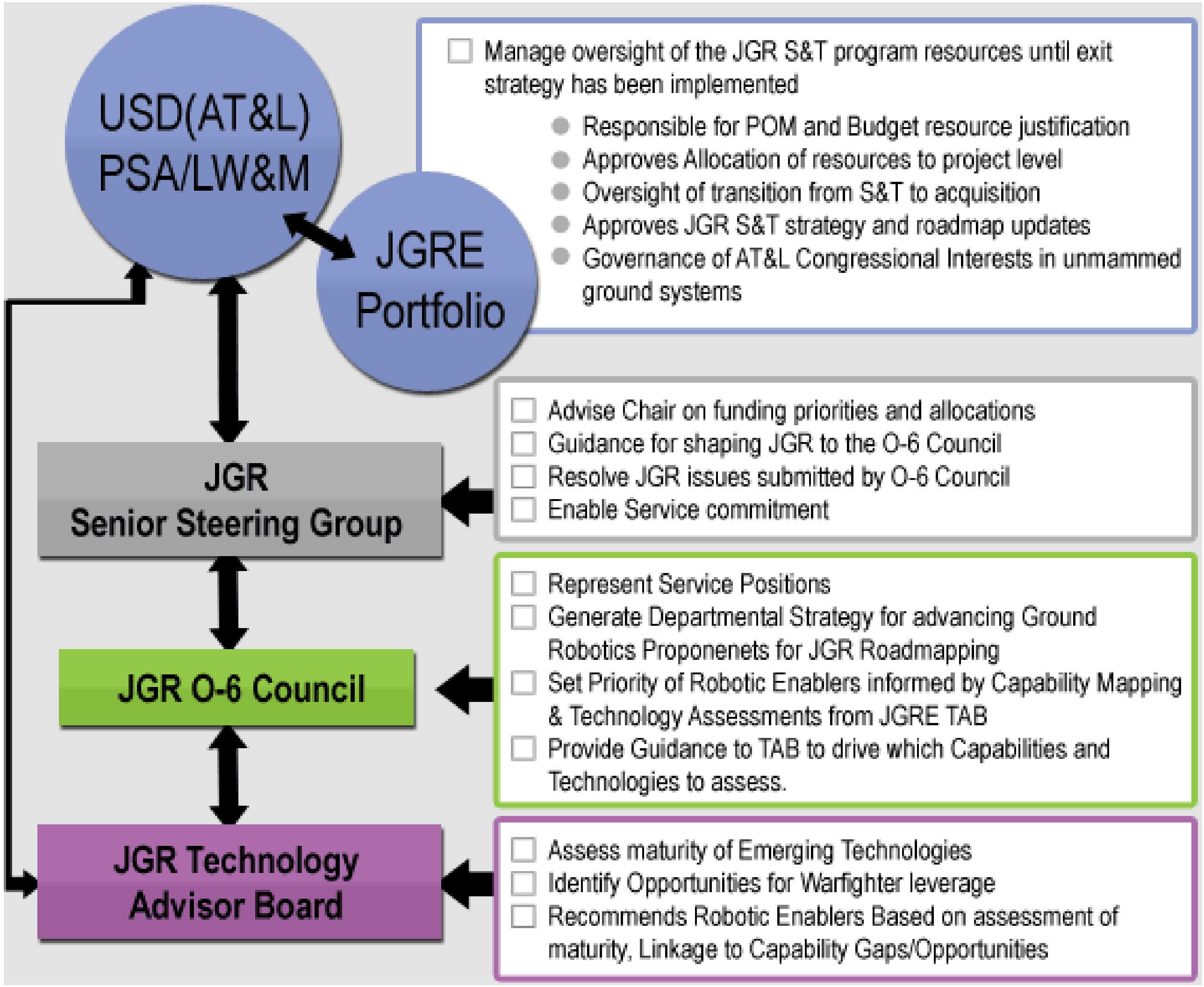
LW&M Placement in DoD



Enterprise Governance



Joint Ground Robotics Enterprise Organizational Structure

Joint Ground Robotics Senior Steering Group

Navy:
Mr. Victor Gavin (MD)
Ms. Carmela Keeney (S&T)
RADM James Shannon (CD)

Marine Corps:
BGen Walter Miller (CD)
Mr. George Solhan (S&T)
BGen Michael Brogan (MD)

Air Force:
BGen Dave Howe (CD)
Mr. Wendell Banks (S&T)

Army:
BG Robert Ogg (MD)
Mr. Donald Sando (CD)
Dr. Grace Bochenek (S&T)
Mr. John Miller (S&T)

Joint Staff:
BGen Glenn M Walters

Mr. Jose Gonzalez - Chair

Joint Ground Robotics Enterprise Organizational Structure

Joint Ground Robotics O-6 Council

LtCol David Thompson (Army/USMC) MD
COL Robert Effinger (Army/TRADOC) CD
Van Chapman (USMC/MCCDC) CD
CAPT Barry Coceano (Navy/OPNAV N85) CD
Paul Milcetic (Navy/EOD) MD
COL David Crow (Air Force/ACC) CD
Al Nease (Air Force/AFRL) MD
CDR Chris Nash (J8)
James Heusman (DTRA)

Dr. Jim Overholt, Dir, JGRE (Chair)

OTA Terms & Conditions

- Period of Performance 7 years
- OTA Price Ceiling $175M
- Phase I authorized: Participation in TAB Process
- Phase I locally authorized to $5M: Research & Development based on funding allocation
- Phase II authorized an additional $170M

Joint Ground Robotics Consortium
12 March - 199 Members

AL - 10
- 7 Trad Small Business
- 3 Non-Trad Small Business

AZ - 2
- 1 Trad Large Business
- 1 Non-Trad Small Business

CA - 30
- 12 Non-Trad Small Business
- 10 Trad Small Business
- 4 Trad Large Business
- 3 Trad Non-Profit
- 1 Trad Academic

CO - 3
- 1 Trad Small Business
- 2 Non-Trad Small Business

CT - 3
- 1 Trad Small Business
- 1 Non-Trad Large Business
- 1 Non-Trad Small Business

DC - 5
- 2 Trad Small Business
- 1 Non-Trad Small Business
- 1 Trad Large Business
- 1 Trad Academic

FL - 3
- 1 Trad Small Business
- 1 Trad Large Business
- 1 Trad Academic

GA - 2
- 1 Trad Small Business
- 1 Trad Academic

HI - 1
- 1 Trad Small Business

ID - 2
- 1 Non-Trad Small Business
- 1 Non-Trad Non-Profit

IL - 2
- 1 Trad Large Business
- 1 Non-Trad Small Business

IN - 2
- 1 Trad Small Business
- 1 Non-Trad Small Business

KS - 1
- 1 Non-Trad Small Business

LA - 2
- 1 Non-Trad Small Business
- 1 Trad Academic

MA - 20
- 9 Non-Trad Small Business
- 3 Trad Small Business
- 6 Trad Large Business
- 1 Non-Trad Academic
- 1 Trad Academic

MD - 11
- 4 Trad Small Business
- 4 Trad Large Business
- 3 Non-Trad Small Business

MI - 17
- 6 Trad Small Business
- 4 Non-Trad Small Business
- 6 Trad Academic
- 1 Non-Trad Academic

MN - 2
- 1 Trad Small Business
- 1 Non-Trad Small Business

NC - 2
- 1 Non-Trad Small Business
- 1 Non-Trad Academic

NH - 4
- 4 Non-Trad Small Business

NJ - 4
- 1 Non-Trad Small Business
- 2 Trad Small Business
- 1 Trad Large Business

NM - 3
- 2 Trad Large Business
- 1 Non-Trad Small Business

NY - 4
- 3 Trad Small Business
- 1 Non-Trad Small Business

OH - 6
- 4 Trad Small Business
- 1 Non-Trad Small Business
- 1 Trad Non-Profit

OR - 1
- 1 Trad Small Business

PA – 25
- 11 Non-Trad Small Business
- 7 Trad Small Business
- 3 Trad Academic
- 2 Trad Non-Profit
- 1 Trad Large Business
- 1 Non-Trad Large Business

SC - 2
- 2 Trad Non-Profit

TN - 1
- 1 Trad Large Business

TX - 10
- 1 Non-Trad Small Business
- 3 Trad Small Business
- 2 Trad Academic
- 1 Non-Trad Academic
- 2 Trad Large Business
- 1 Trad Non-Profit

UT - 3
- 3 Non-Trad Small Business

VA - 10
- 5 Non-Trad Small Business
- 3 Trad Small Business
- 1 Trad Academic
- 1 Non-Trad Non-Profit

WA - 2
- 1 Non-Trad Small Business
- 1 Trad Academic

WI - 1
- 1 Trad Large Business

WV - 1
- 1 Trad Non-Profit

WY - 2
- 1 Trad Academic
- 1 Trad Small Business

Joint Ground Robotics Enterprise Organizational Structure

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Mr. John Miller (S&T)

Joint Staff:
BGen Glenn M Walters

RTC:
Mr. Bill Thomasmeyer
Mr. Andy Dallas
Mr. Jorgen Pedersen
Mr. Lee Buchanan

Mr. Jose Gonzalez, Ms. Helen Greiner – Co-Chairs

FY10 TAB Members

Battlespace Awareness

P. Rowe	J. Lasswell
T. Cable	M. Bruch
W. English	Lt. Hobson
B. McBride	G. Hudas

Force Application

W. English	J. Bradel
B. McBride	M. Bruch
P. Rowe	B. Skibba
K. Kirkpatrick	R. Wade

Protection

K. Massey	J. Bradel
D. Theobold	B. Brezina
P. Koon	B. Skibba
T. Cable	R. Wade

Logistics

K. Kirkpatrick	J. Lasswell
P. Koon	B. Brezina
D. Theobold	Lt. Hobson
K. Massey	Greg Hudas

Dr. Jim Overholt; Andrew Dallas - Co-chairs

Agenda

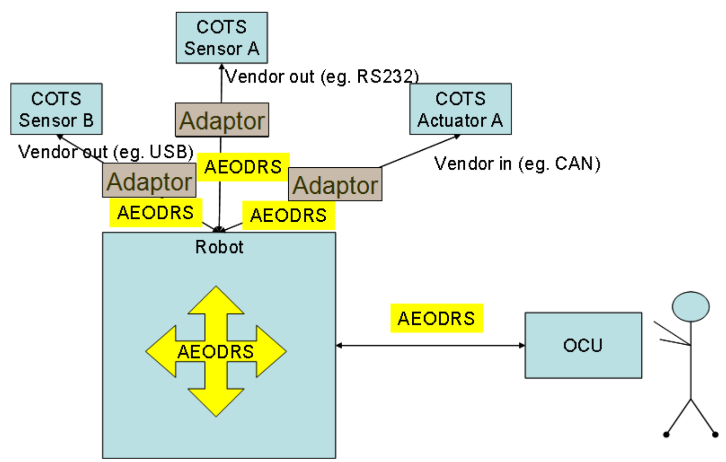
- Congressional Language
- JGRE Overview and Organizational Structure
- JGRE Success Stories
- Robotics Range Clearance Competition (R2C2)

Success Stories USMC

- Enhanced Company Operations, Limited Objective Experiment 3.2
  - Main Objective: Evaluate the utility of a UGV in:
    - Supply distribution for small units operating beyond the capability of mutual support
    - Casualty evacuation for small units operating beyond the capability of mutual support
      - The technologies provided through the JGRE allowed the Marine Corps Warfighting Lab to conduct a live-force experiment which met the Main Objective
  - Results: Concept of Operations developed for UGV's has merit
    - Further experimentation and refinement before transition
  - Recommendation: Expand on unmanned re-supply experimentation
    - Continue with higher MAGTF level experimentation
    - Refinement on the ConOps for future experimentation informed by the results of ECO LOE-3.3

Success Stories NAVY

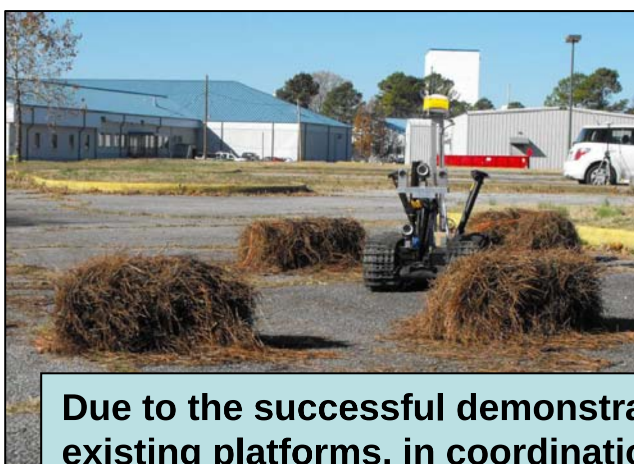
- Advanced EOD Robot System (AEODRS)
  - Scheduled for MS B 4QFY10
  - Matured Modular Manipulators and End Effectors
  - Matured Hybrid Power and Energy Systems for Robots
  - Tracking 50 technologies/efforts that may be leveraged by AEODRS
  - Completed Common System Architecture Roadmap
  - Established preliminary optimal definition of EOD robot family



AEODRS will have an extensible, open architecture which prescribes relevant interfaces and is configuration controlled by the Government.

Success Stories ARMY

- Computer Assisted Robotic Manipulator (CARMAN)
  - Provide increased precision of manipulator contro and increased ease of operation
    - 30% reduction in the time required to manipulate the robotic arm;
    - 70% reduction in the number of inadvertent contacts of the manipulator arm
- Computer Assisted Tele-Operation (CATO)
  - Improves the tele-operated mobility of Unmanned Ground Vehicles through an improved interface
    - 20% reduction in straight line error (i.e. swerving);
    - 30% reduction in the number of inadvertent contacts while navigating



Due to the successful demonstration, these technologies are being inserted into existing platforms, in coordination with the NSWC EOD Technology Division.

Success Stories ARMY/Air Force

- Joint Architecture for Unmanned Systems- SAE AS5684, JAUS Interface Definition Language
  - Mobility Service Set – Complete, balloted and passed
  - Manipulator Service Set – Draft complete and balloted once – in revision
  - Environment Sensing Service Set – Draft complete and balloted once – in revision
  - Mission Execution Service Set – Complete, balloted and passed
  - All service sets have been drafted and balloted. They are in revision and will be presented to the committees for final approval. Final approved versions expected by the end of Q3 – 2010.

Success Stories Air Force

- Autonomous Range Clearance
  - Successful demonstration of autonomous range clearance tasks and preliminary data have led the US Army to allocate funds for procurement of autonomous range clearance systems assuming successful results from Range Clearance Cash Prize Competition (R2C2)
  - R2C2 planning is ongoing to support competition in Aug/Sep 2011

Agenda

- Congressional Language
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- Robotics Range Clearance Competition (R2C2)

Robotic Range Clearance Competition Goal

- Advance the state of the art in robotics thru range clearance technologies
- $2 Million in cash prizes
- G3/5/7 releasing an IDIQ

Why Range Clearance?

- Currently there are millions of acres encumbered with spent training rounds and munitions debris
- The competition will help provide a safer, more timely, and more cost effective way to return the land to productive use

Robotic Range Clearance Competition (R2C2) Events

- Kick-off Meeting was held 22 October
- Industry Day was held 10 December
- Letter of Intent
  - Posted 26 February via www.roboticrangeclearance.com
  - Due date of 3 May
- Competition Rules
  - Posted 26 February via www.roboticrangeclearance.com

R2C2 Future Events

- Pilot run beginning of August 2010
- Open competitor test runs at Camp Guernsey
  - 1 August 2010-1 November 2010
  - 1 May 2011-1 July 2011
- In Progress Reviews (IPRs) at competitor sites 1-19 November 2010
- Final Competition scheduled Summer 2011
  - Will be held at Camp Guernsey in Guernsey, WY

Prize Scope

- Unmanned vegetation clearance ($250K)
- Unmanned geophysical mapping ($250K)
- Unmanned surface debris clearance ($250K)
- Unmanned sub-surface UXO clearance ($250K)

- **End Goal: Range Area Cleared of UXO ($1M) using Unmanned Technologies**

Focus is on increasing safety and operational effectiveness via robotics automation as well as reduce time and cost

Why Compete?

- OSD is offering prize money for the system that is most advanced and scores the highest
- Army Corps of Engineers in conjunction with the Army G3/5/7 will be releasing an IDIQ contract
  - Procure Services for Robotic Range Clearance
  - Participation in the competition will give competitors an opportunity to show the government success of their systems
  - Data collected for the competition can be used as test data to demonstrate capabilities for the IDIQ

Summary

- DoD is looking for the Robotics Range Clearance Competition to:
  - Advance the state of the art in robotics range clearance technologies
  - Foster opportunity for COTS procurement for Robotic Range Clearance
  - Provide the best balance of efficiency and innovation in robotic technology development
- Hope we see you at the Competition!

R2C2 Questions

- Please stop by the AFRL booth (211) or fill out a questions form on the roboticrangeclearance.com site

PEO LMW

Presentation to:

2010 GROUND ROBOTICS CAPABILITIES CONFERENCE

Victor S. Gavin, Executive Director

18 March 2010

Role of PEO Littoral & Mine Warfare

- **Originally established in 1992 as PEO Mine Warfare (PEO MIW)**

18 years of "culture"

- **Realigned as *PEO Littoral and Mine Warfare (PEO LMW) OCT 2002* assigning increased responsibility for Undersea and Littoral Warfare programs**

- **PEO LMW designs, delivers and maintains the systems, equipment and weapons needed by the warfighter to dominate the littoral battlespace and provide the *Warfighter Assured Access!***

.....and growing!

- **PEO LMW is comprised of 165 civilians and 35 military supplemented by Field Activities and other personnel responsible for the *development, acquisition, and life-cycle support of more than 220 systems.***

Program Executive Officer Littoral and Mine Warfare

Program Executive Officer
Ms. E. A. Sandel
202-781-3900

Chief Financial Officer
Ms. E. Straub (Acting)
202-781-3236

Director of Acquisition
Mr. P. Hullinger (Acting)
202-781-3236

Chief Logistician
Mr. T. Gregory (Acting)

Communications Director
Mr. G. Schein
202-781-2219

Chief of Staff
CAPT J. Chisum
202-781-3902

Director for Corporate Operations
Ms. G. Baker
202-781-3903

Executive Assistant
Ms. T. Yingling
202-781-3904

Executive Director
Mr. V. Gavin
202-781-3901

PMS340
NAVAL SPEC WARFARE PROGRAM OFFICE
CAPT P. Sullivan
202-781-0758

PMS340 DEPUTY
Mr. R. Stephenson
202-781-0884

PMS403
UNMANNED MARITIME VEHICLE PROGRAM OFFICE
CAPT P. Siegrist
202-781-1393

PMS403 DEPUTY
Mr. M. Alperi
202-781-4444

PMS420
MISSION MODULES PROGRAM OFFICE
CAPT M. Good
202-781-2303

PMS420 DEPUTY
Mr. P. Marshall
202-781-4469

PMS480
ANTI-TERRORISM AFLOAT PROG OFC
CAPT J. Day
202-781-0531

PMS480 DEPUTY
Mr. A. Schuler
202-781-3279

PMS485
MARITIME SURVEIL. SYS PROG OFC
CAPT J. Ferrer
858-537-0283

PMS485 DEPUTY
Mr. R. MacKinnon
619-524-7653

PMS495
MINE WARFARE PROGRAM OFFICE
Ms. D. Carson-Jelley
202-781-1842

PMS495 DEPUTY
CAPT J. Hardison
202-781-2458

PMS408
CREW/EOD PROG OFC
CAPT J. Neagley
202-781-2066

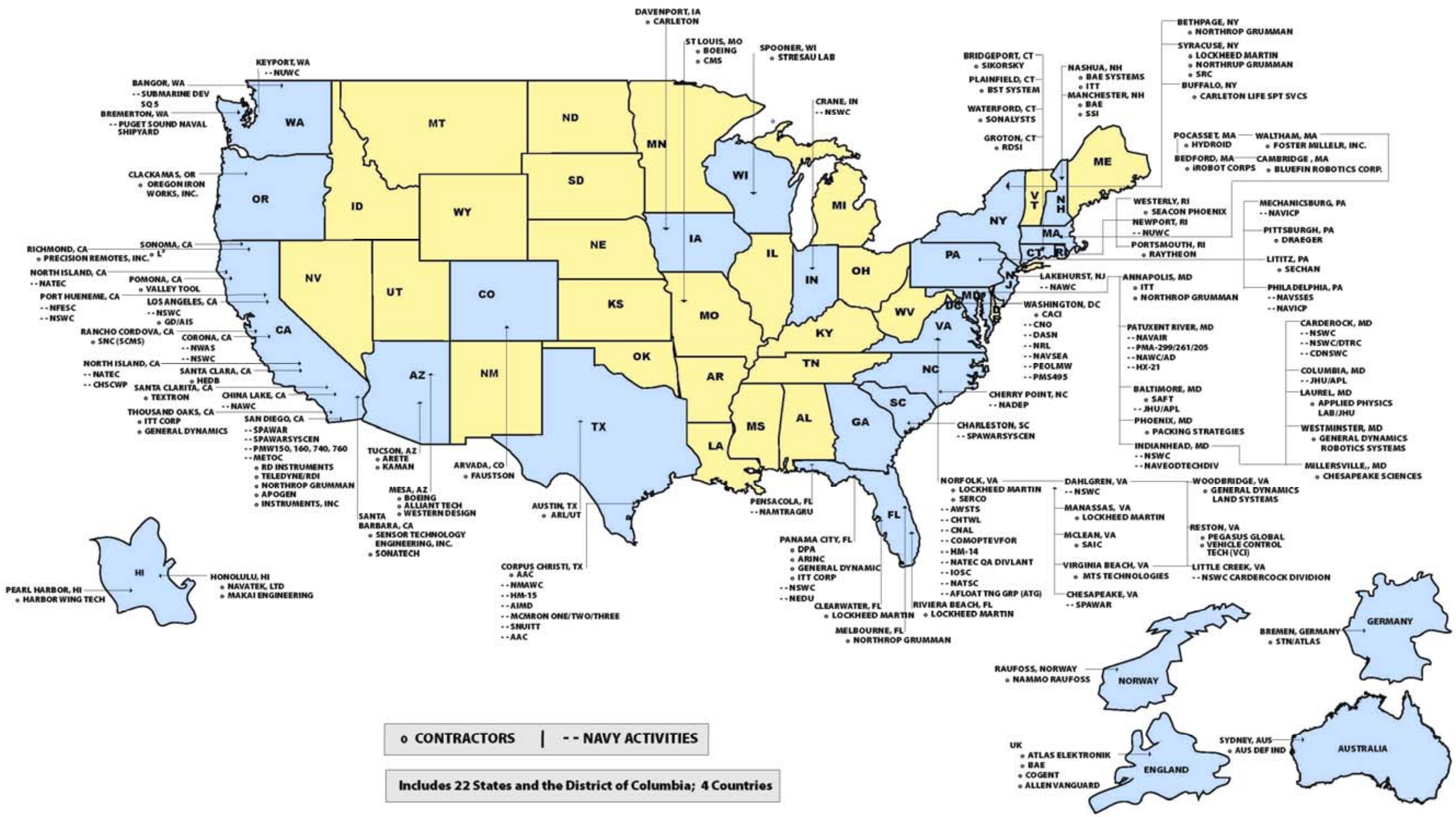
PMS408/EOD DEPUTY
CDR A. Peters
301-744-6839

PMS408/CREW DEPUTY
Mr. P. Anderson
202-781-2822

PMS-AT-ASHORE
ANTI-TERR.ASHORE PROG OFC
Mr. D. Kim
202-685-9334

PMS-AT-ASHORE DEPUTY
Mr. J. McConnell
202-685-9371

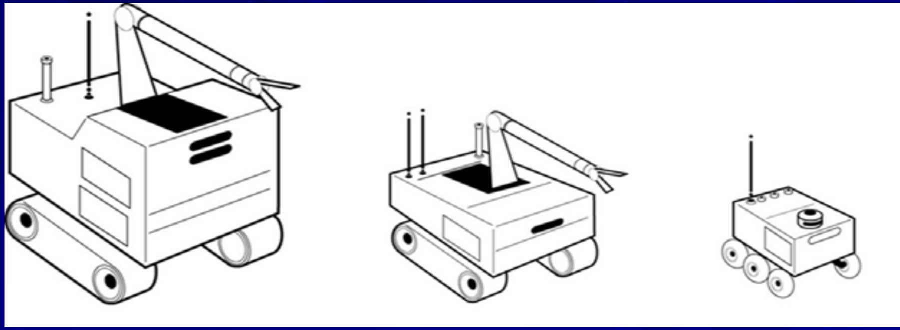
PEO LMW Industrial & Government Partners



MK 1 & MK 2 Explosive Ordnance Disposal (EOD) ROBOTS

- Mission
  - **Complement/augment the EOD technician when performing reconnaissance, render safe, and disposal during EOD missions**
  - **Indoor/outdoor**
  - **Improvised Explosive Devices (IEDs) and Unexploded Ordnance (UXO)**
- Characteristics
  - **Easily transportable and quick set-up**
  - **Indoor operation - stairs, doorways**
  - **Outdoor operation - slopes, mud, high grass, rubble**
  - **2 hr endurance**
  - **Range - 800m (wireless), 200m (tethered)**
  - **Interoperable with EOD tools**
- Full Life-Cycle Support for both configurations
- Systems fielded:
  - **1,868 MK 1 & MK 2 EOD Robots**

ADVANCED EOD ROBOTIC SYSTEM (AEODRS)



- **Family of robotic systems composed of three variants:**
  - **Dismounted Operations**
  - **Tactical Operations**
  - **Base/Infrastructure Operations**
- **Family is characterized by the interoperability of its subsystems via Government-controlled logical, electrical, and physical interfaces and the commonality of its Operator Control Unit (OCU)**
- **Family is also characterized by the interchangeability of its initial subsystems with future subsystems that can be procured using full and open competition**
- **DoD Modular Open Systems Approach (MOSA) Policy**
- **Draft Capability Development Document (CDD) in review / approval process**
- **Milestone B planned for September 2010**

AEODRS SELECTED PRELIMINARY REQUIREMENTS

- Dismounted Operations
  - Back-packable, 35 lbs including backpack
  - 100 meter range
  - Low Degree-of-Freedom manipulator, 5 lbs lift at full extension
  - Able to travel through 18 inch culvert
- Tactical Operations
  - Vehicle two-man transportable for short distances – no greater than 164 lbs
  - 1000 meter range
  - Dual Arm Manipulator – Lift 44 lbs at full extension, 110 lbs close-up
- Base/Infrastructure Operations
  - System weight – 750 lbs
  - 1200 meter range
  - Dual Arm Manipulator – Lift 75 lbs at full extension, 300 lbs close-up
- Autonomy
  - Point and Click navigation with obstacle detection and obstacle avoidance
  - Automatic end effector changeout
  - Point and Click end effector positioning

SUMMARY

- **AEODRS is the fourth generation of military EOD robots**
- **AEODRS is being developed as a family of systems using a modular open systems approach**
- **The up-front focus on subsystem interoperability and interchangeability will enable faster acquisition with demonstrated technology, provide continued access to state-of-the-art technologies, and prevent being locked into a proprietary system**

PMS 408 (EOD) POCs for Joint Service EOD Robotics

- **Deputy, Program Manager EOD**
  - **CDR Aaron S. Peters, email: aaron.s.peters@navy.mil, phone: 301-744-6839**
- **Deputy Director, EOD Programs**
  - **Eric C. Hoffman, email: eric.c.hoffman@navy.mil, phone: 301-744-6838**
- **Joint Service EOD Assistant Program Manager**
  - **Chris Fawls, email: chris.fawls@navy.mil, phone: 301-744-6906**

Robotics for Space Exploration Today and Tomorrow

Chris Scolese

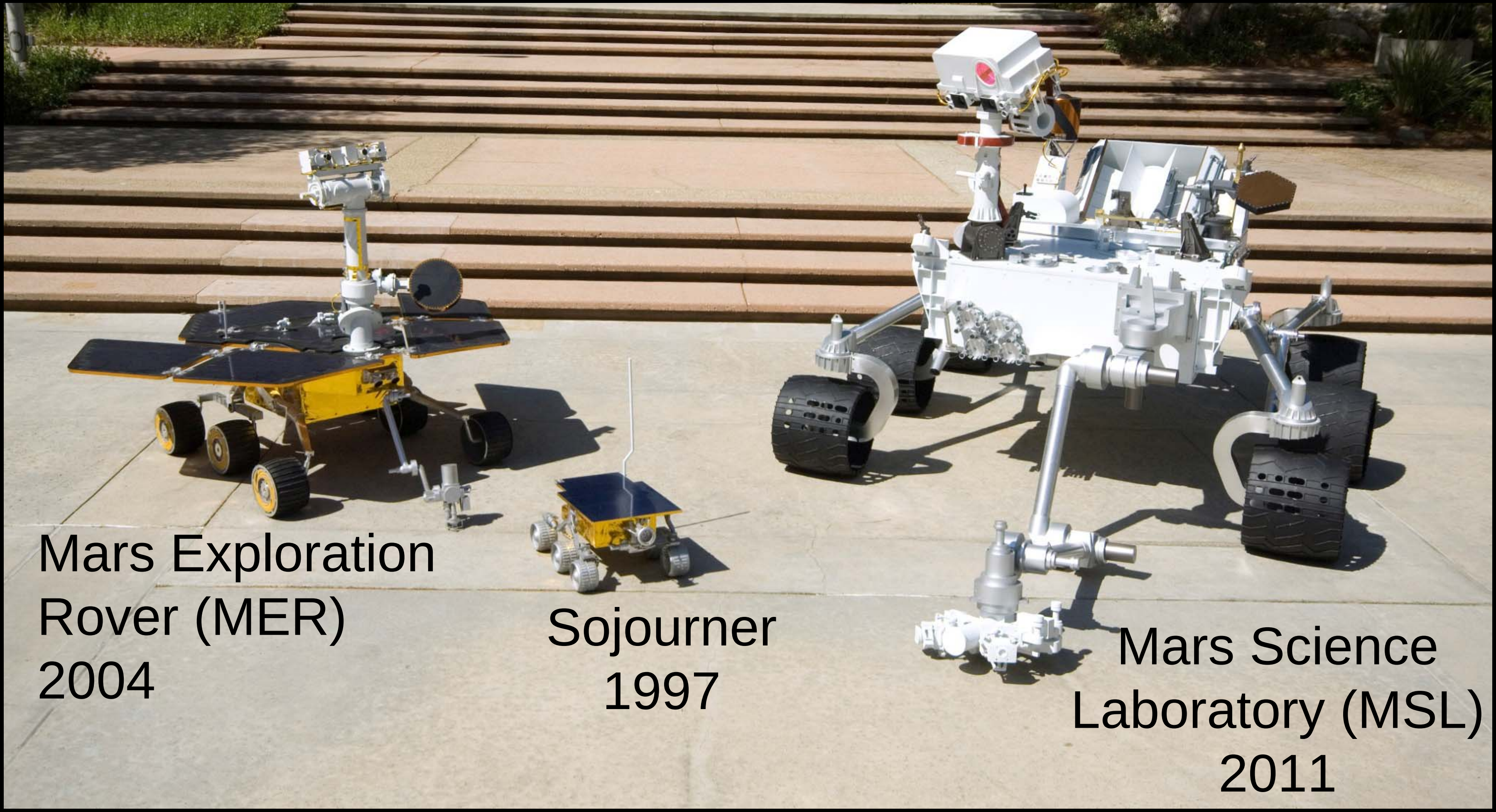
NASA Associate Administrator

March 17, 2010

The Goal and The Problem

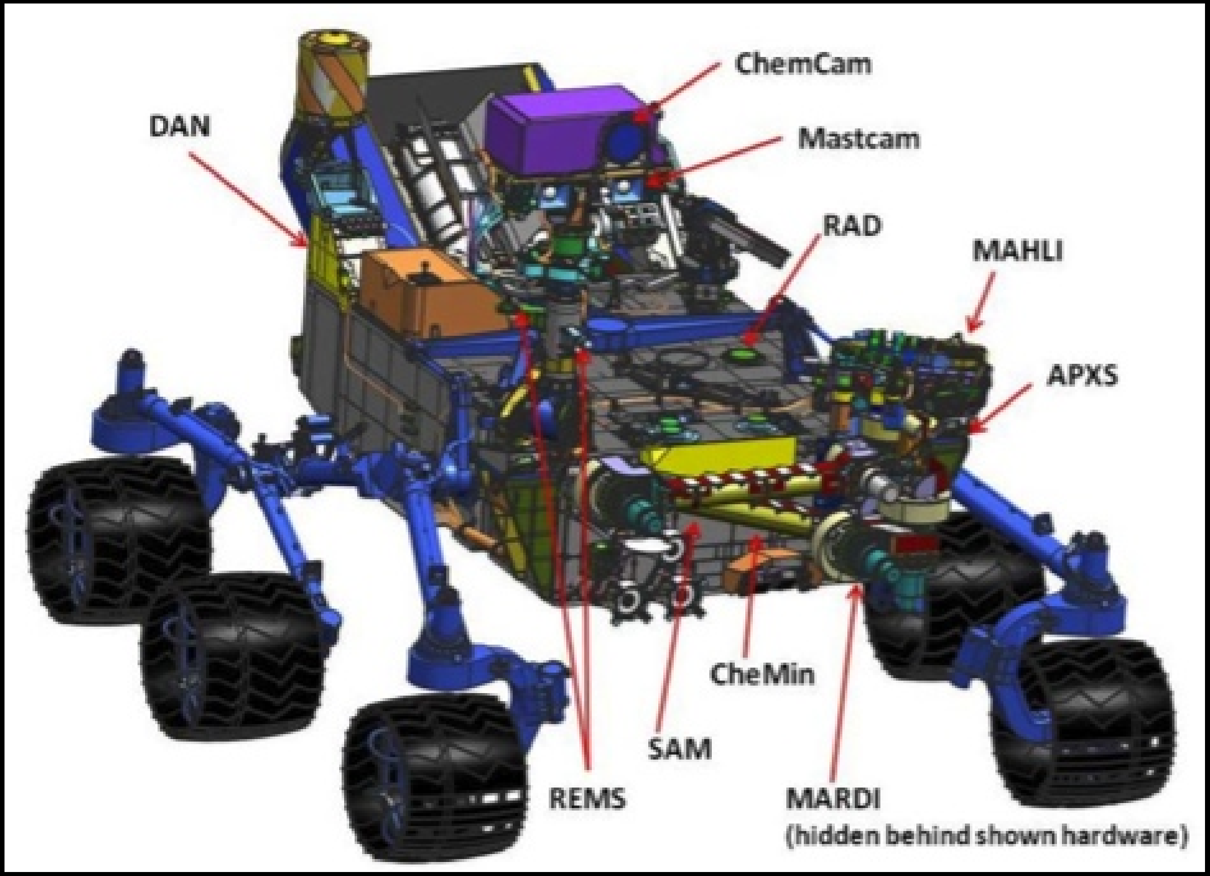
- Explore planetary surfaces with robotic vehicles
  - Understand the environment
  - Search for signatures of life
  - Prepare for eventual human exploration
- Time delays range from minutes to hours
- Many unknowns
  - Atmospheric conditions
  - Surface conditions
  - Winds
  - Location of hazards

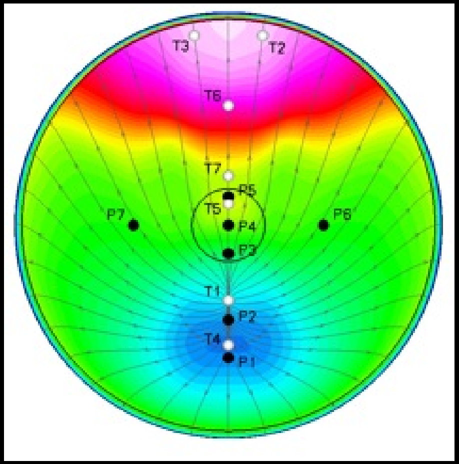
Past, Present and Future Rovers



(Photo: NASA/JPL/Thomas “Dutch” Slager)

Mars Science Laboratory (MSL)

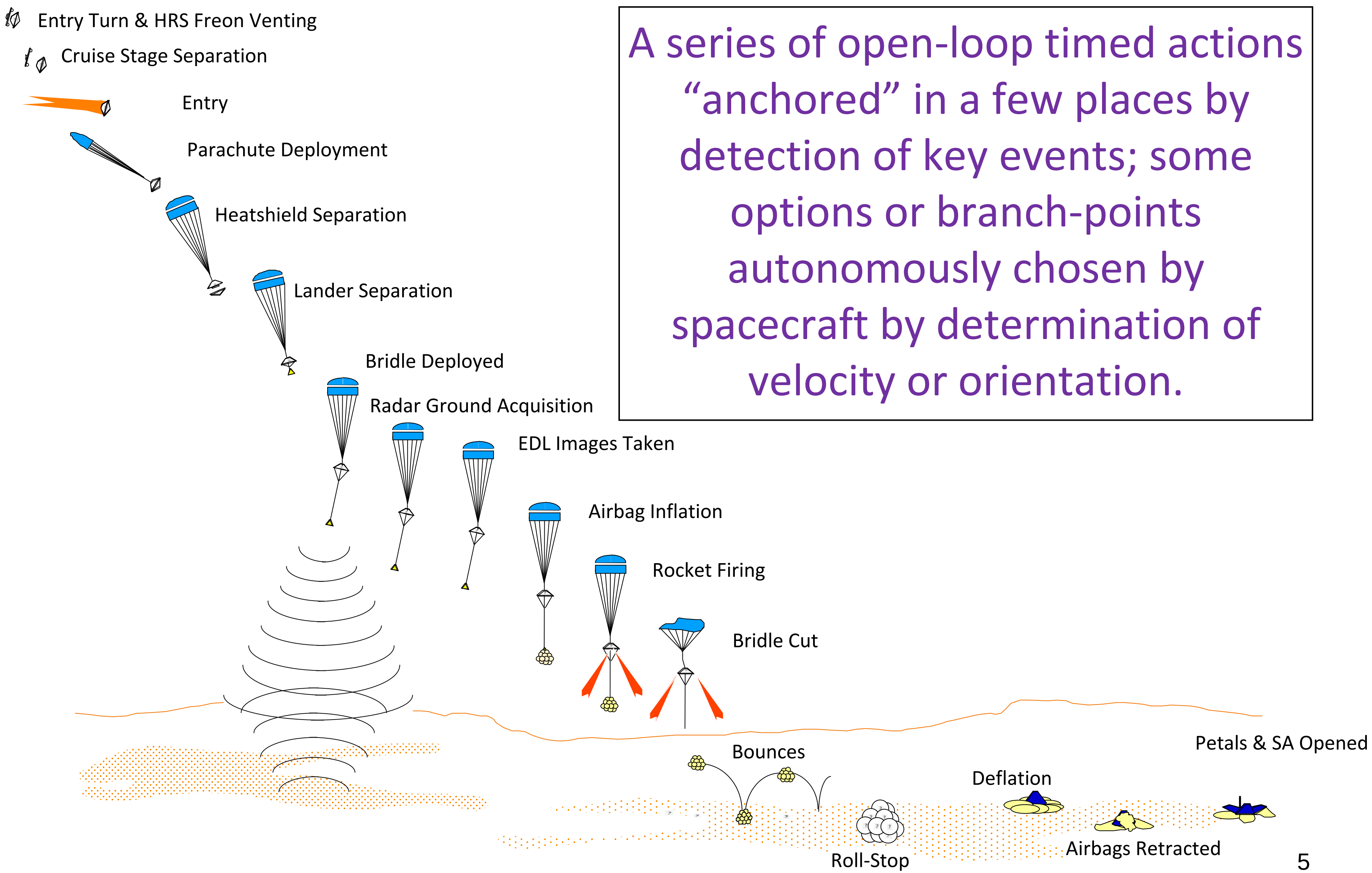




Predicted heat flux during EDL

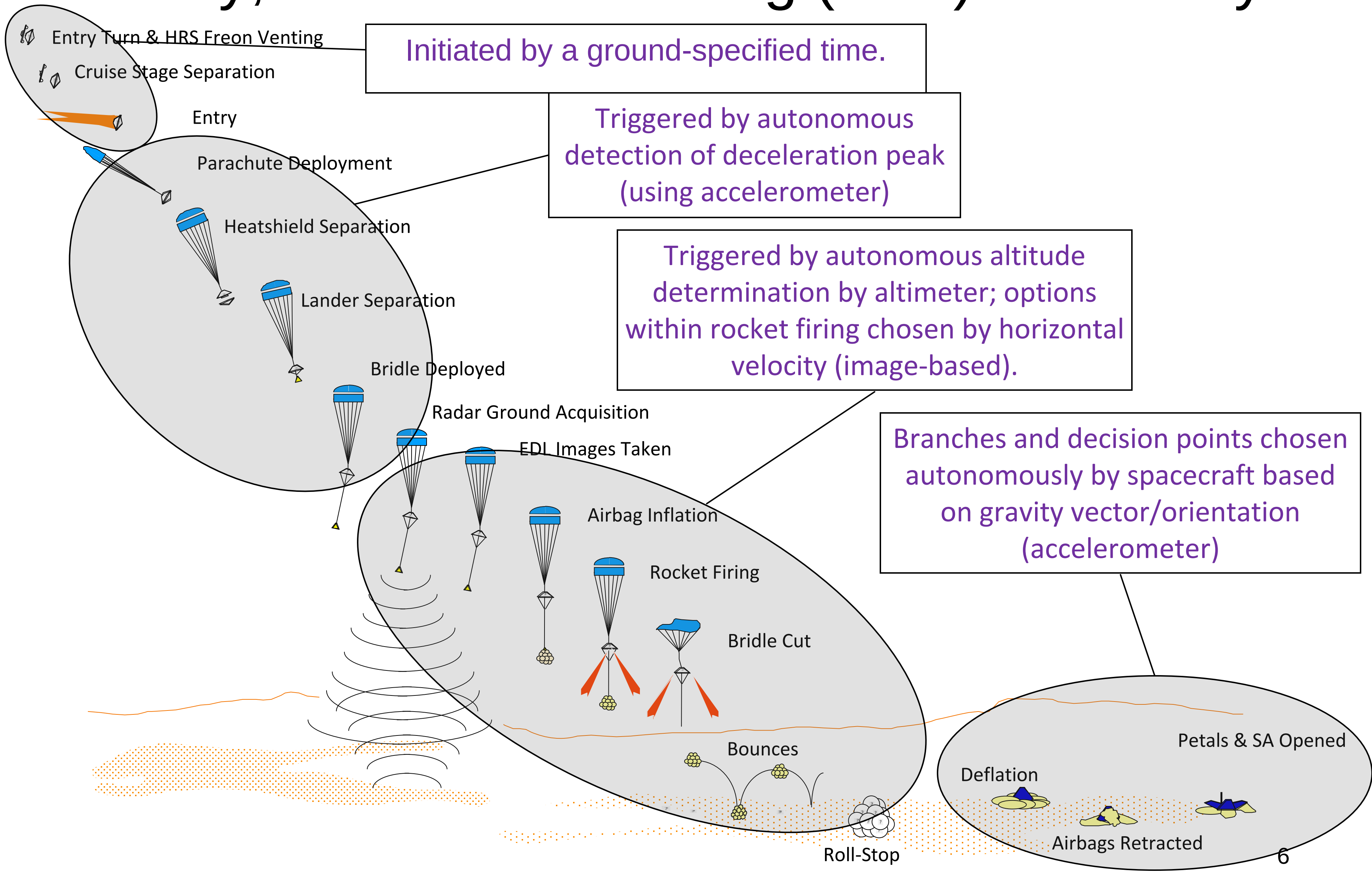
Mars Descent Imager (MARDI)

Mars Exploration Rovers (MER)
Entry, Descent & Landing (EDL) Autonomy

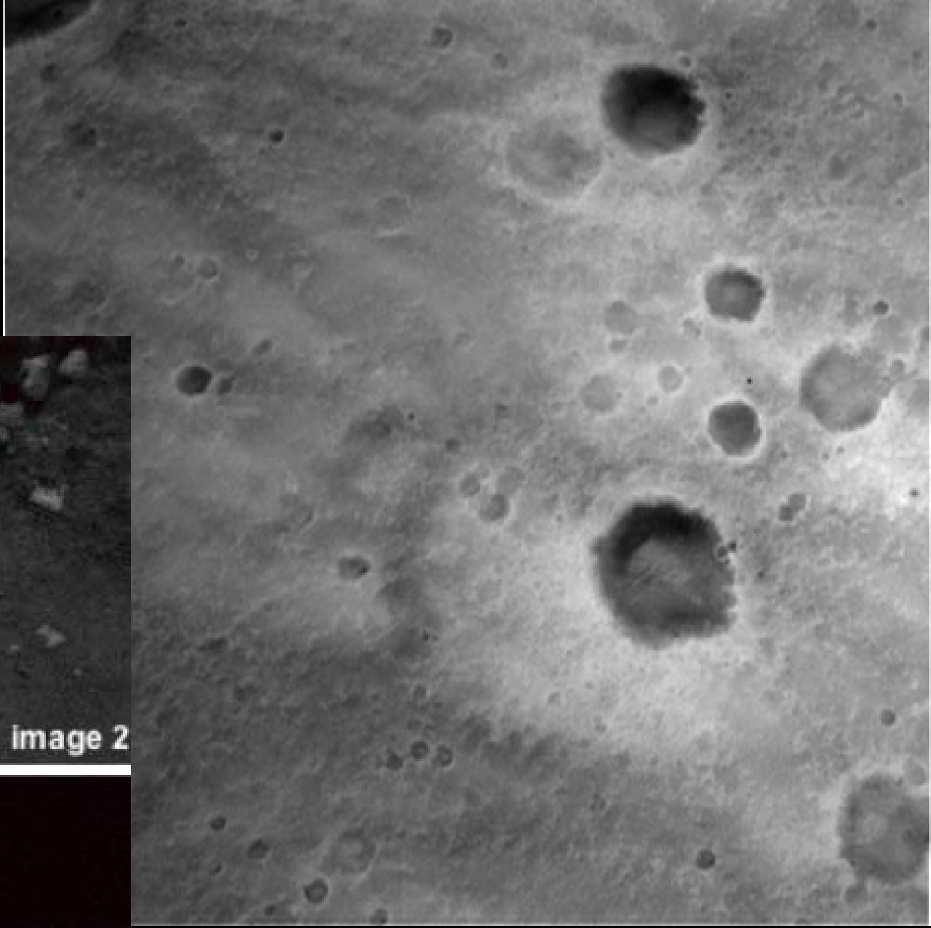


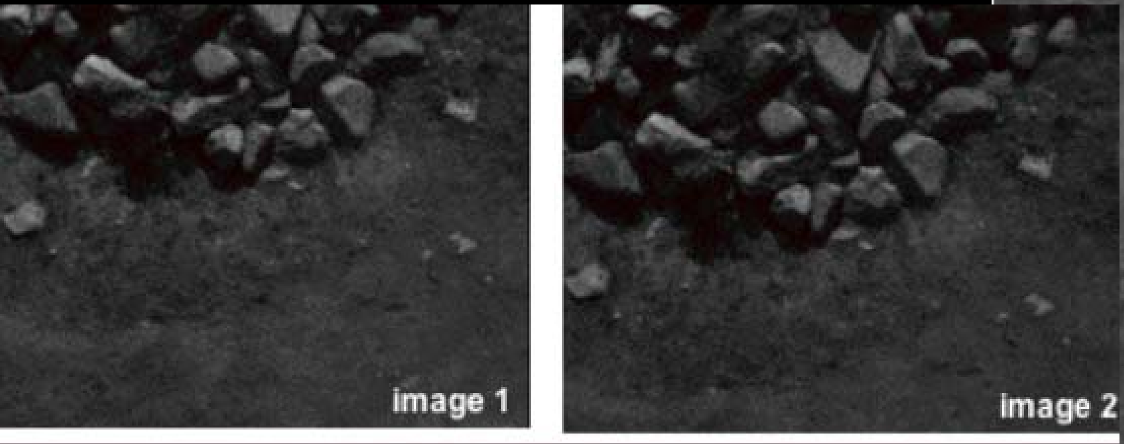
A series of open-loop timed actions "anchored" in a few places by detection of key events; some options or branch-points autonomously chosen by spacecraft by determination of velocity or orientation.

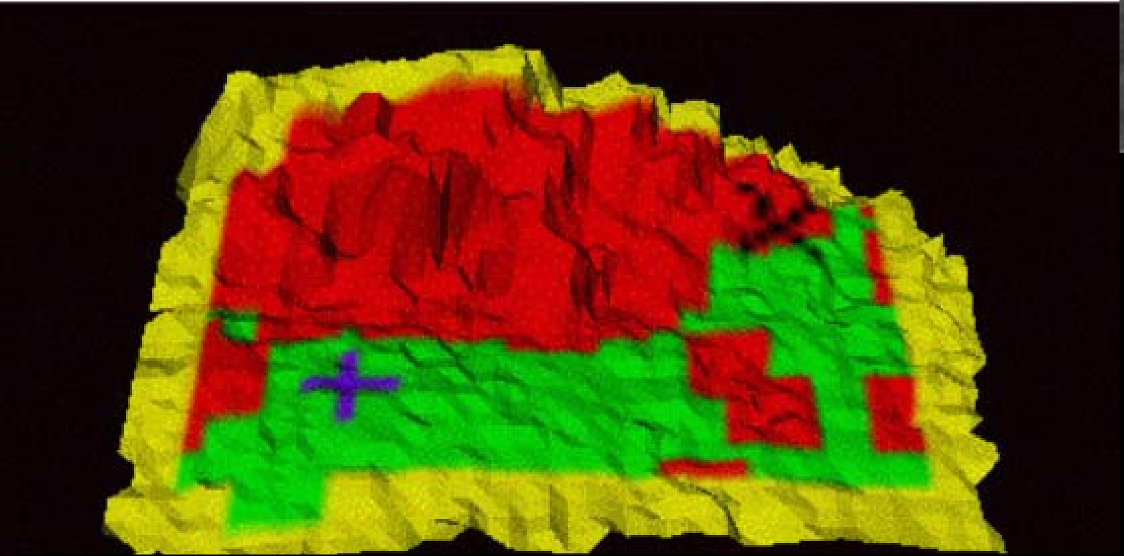
Mars Exploration Rovers (MER) Entry, Descent & Landing (EDL) Autonomy



MER Entry, Descent, & Landing



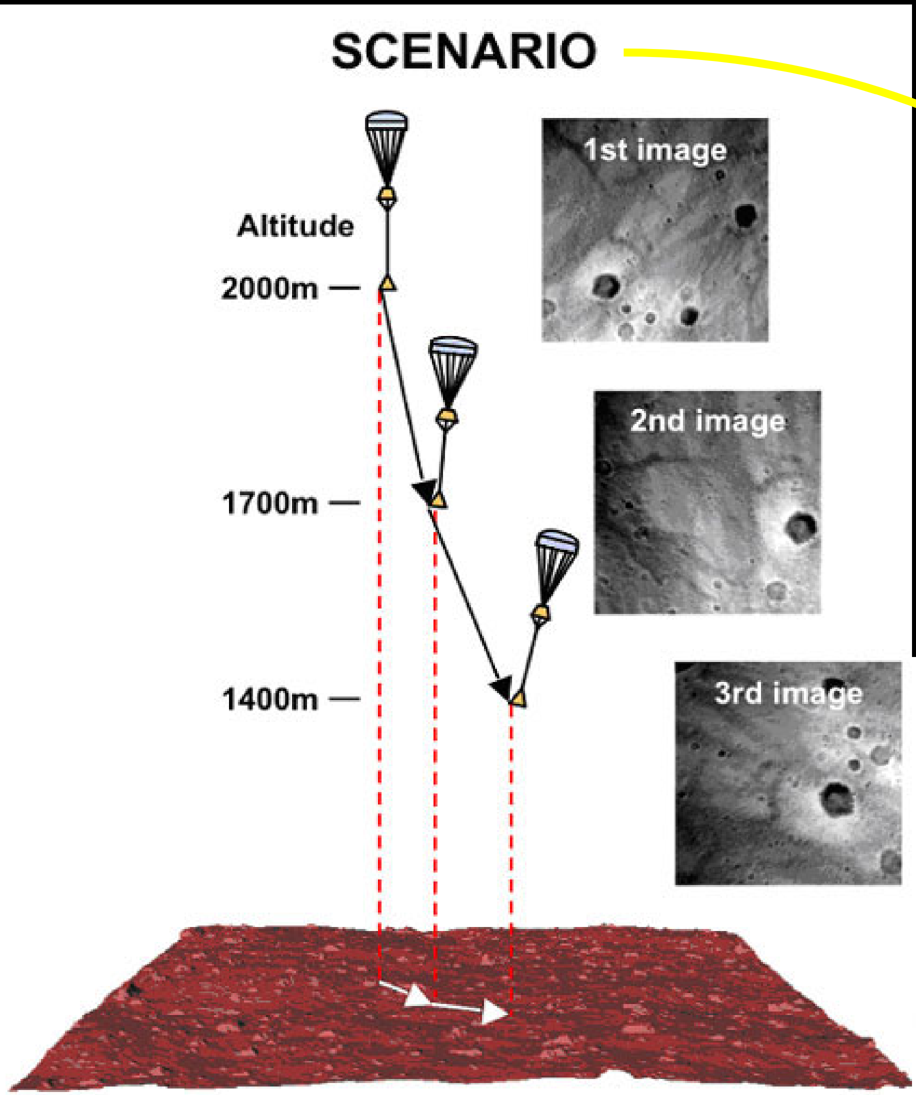




Safe landing map on terrain

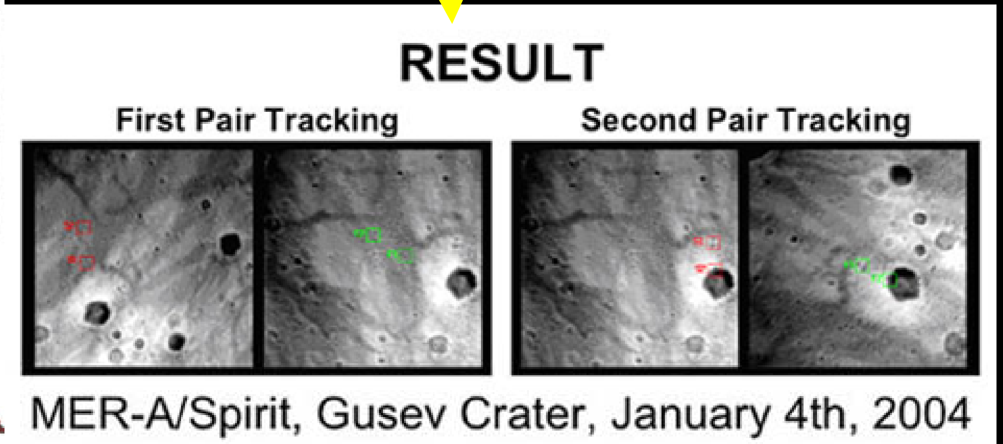
Descent image motion estimation subsystem (DIMES)

MER Entry, Descent, and Landing 1



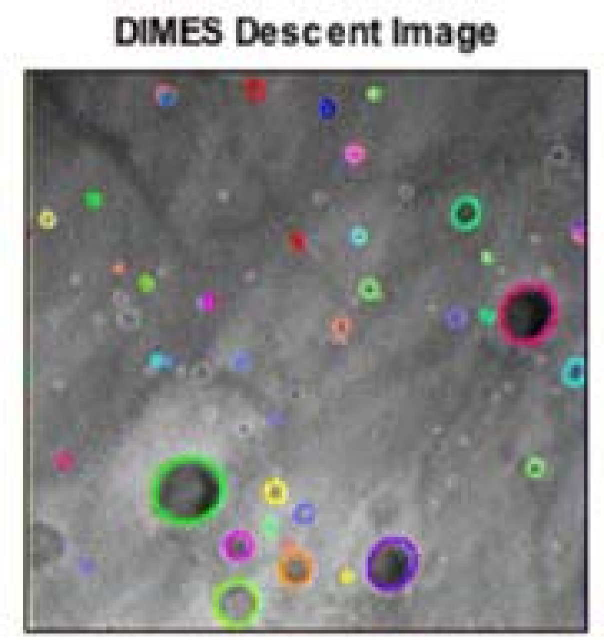
Entire EDL system is autonomous.

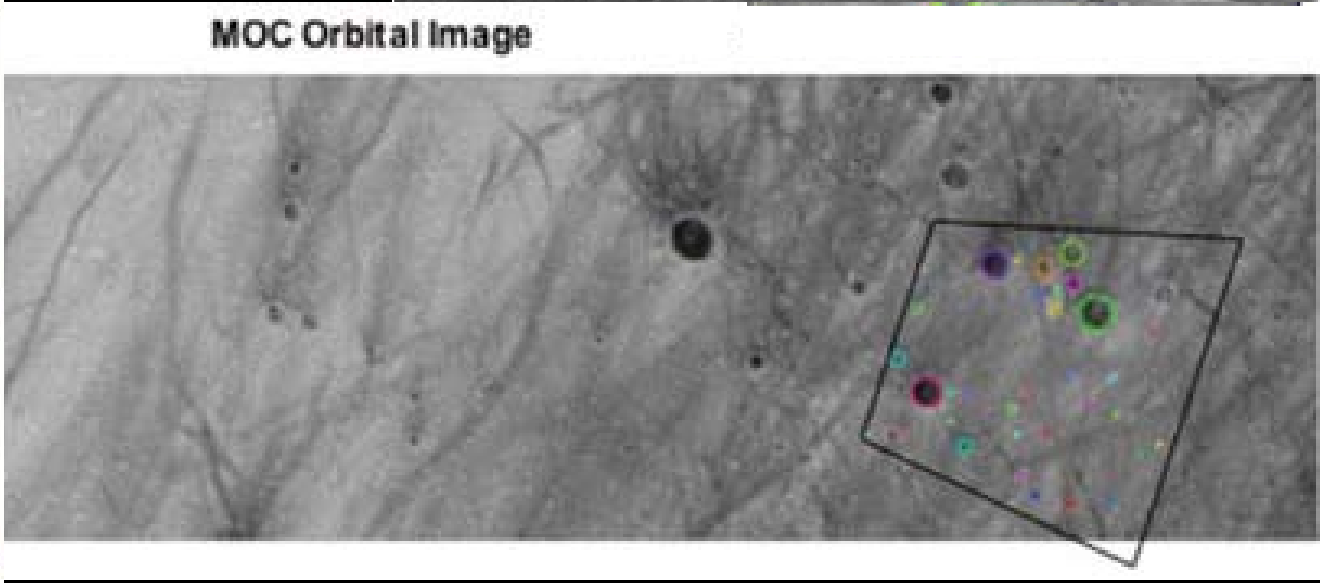
Descent image motion estimation subsystem (DIMES)



MER Entry, Descent, and Landing 2

Descent image motion estimation subsystem (DIMES)

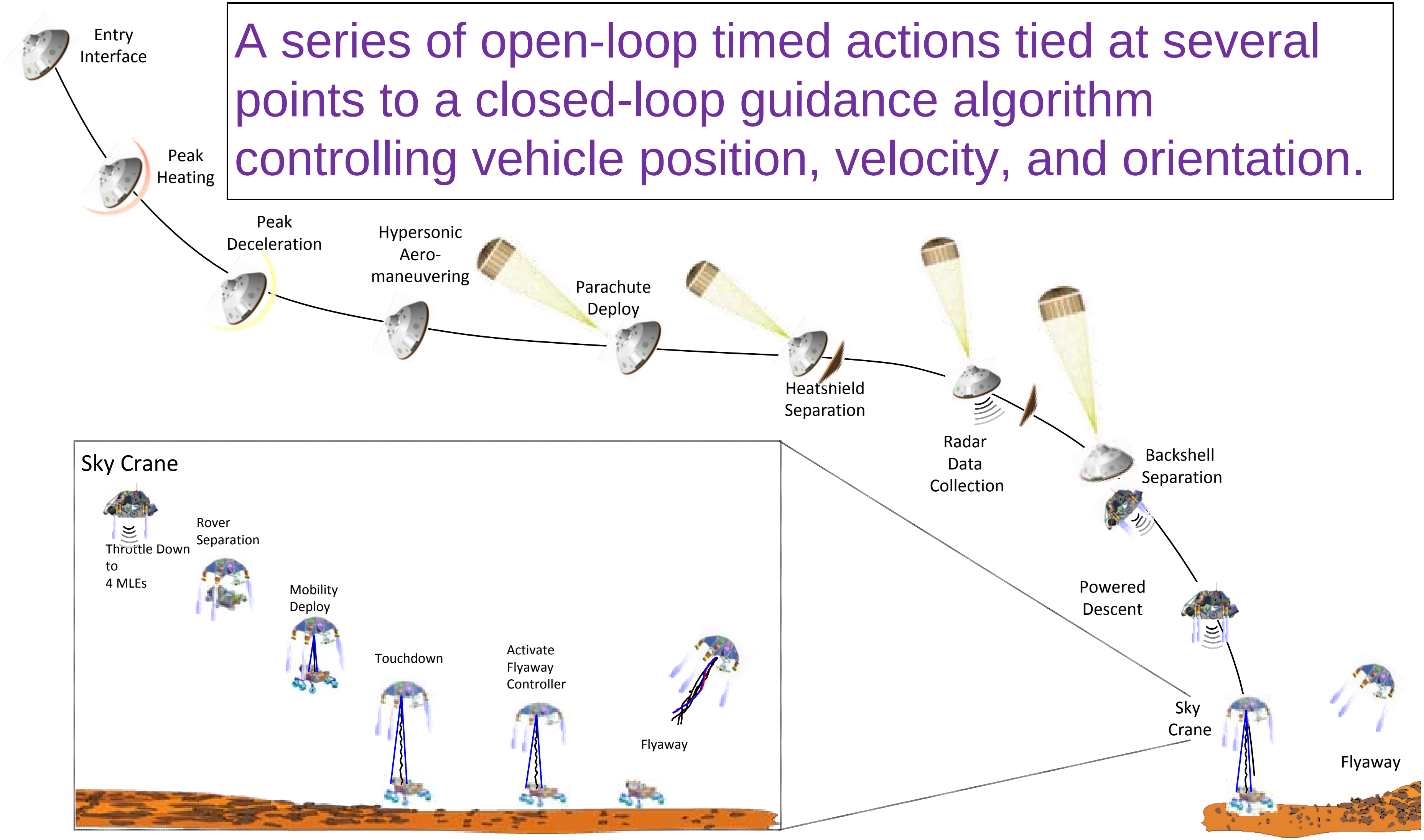




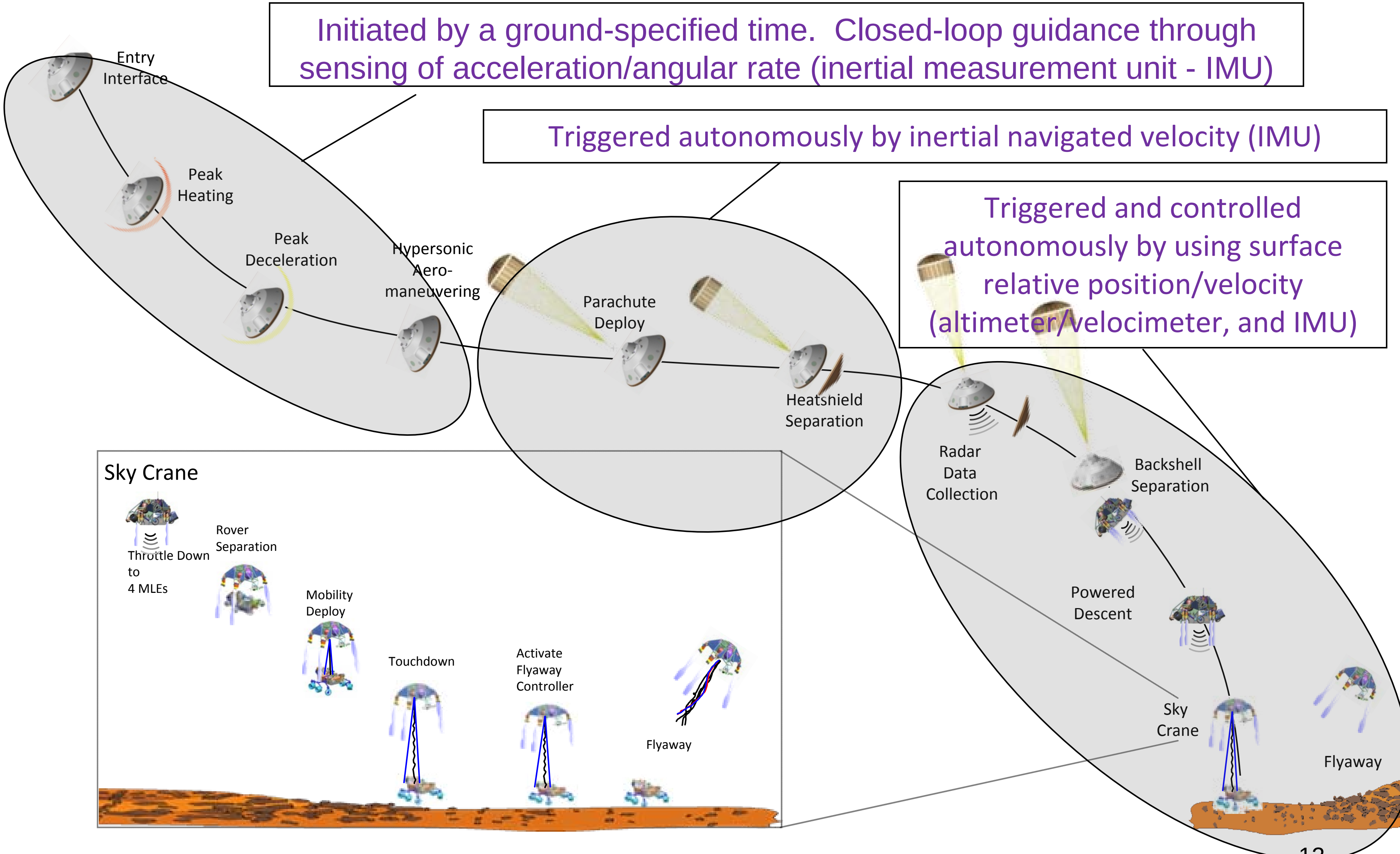
Phoenix on the Chute

Mars Science Laboratory (MSL) Entry, Descent & Landing (EDL) Autonomy

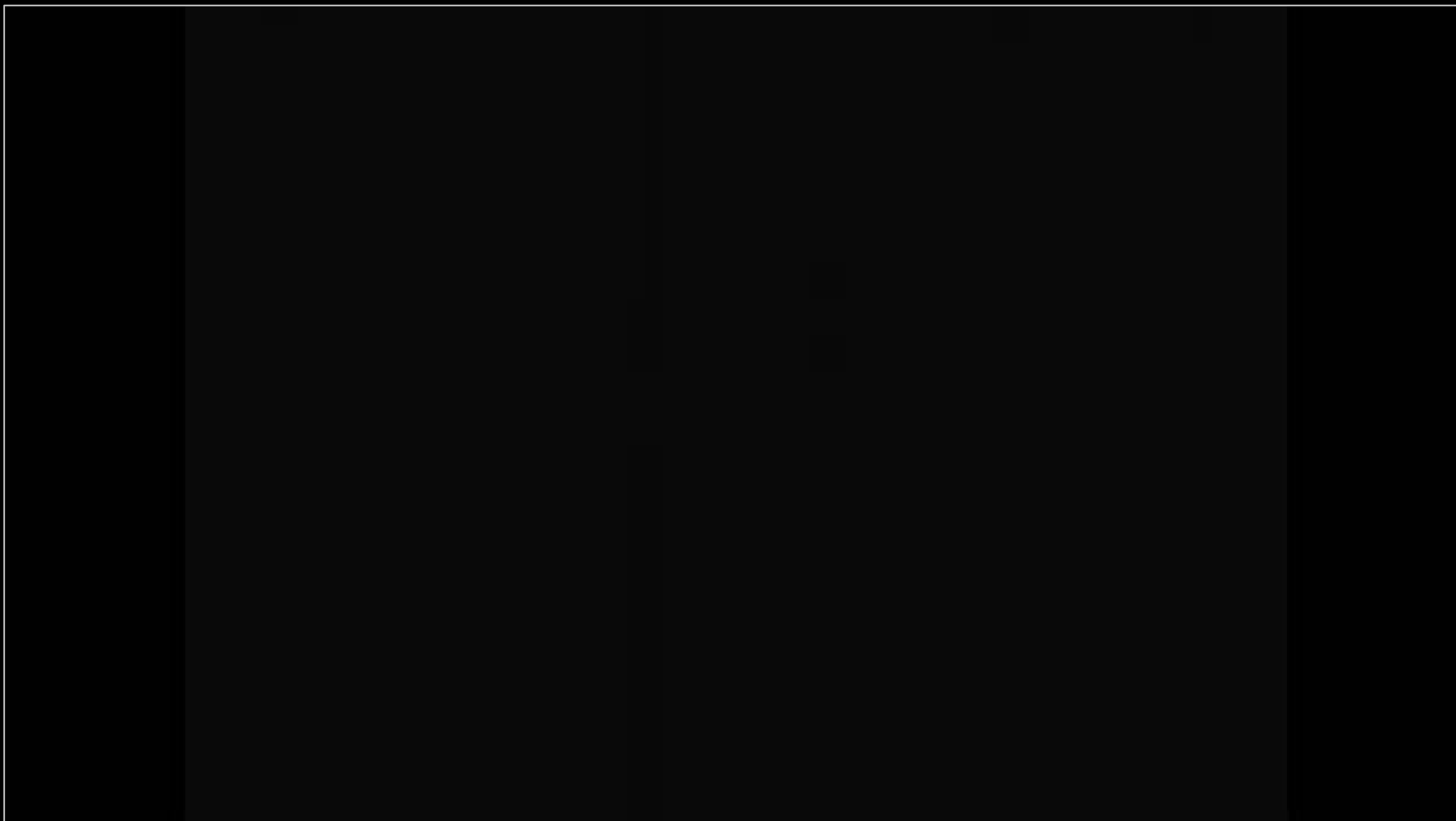
A series of open-loop timed actions tied at several points to a closed-loop guidance algorithm controlling vehicle position, velocity, and orientation.



Mars Science Laboratory (MSL)
Entry, Descent & Landing (EDL) Autonomy



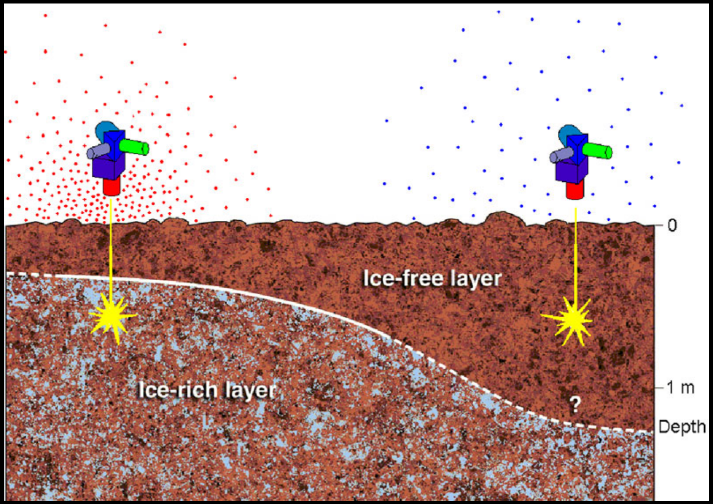
MER Entry, Descent & Landing



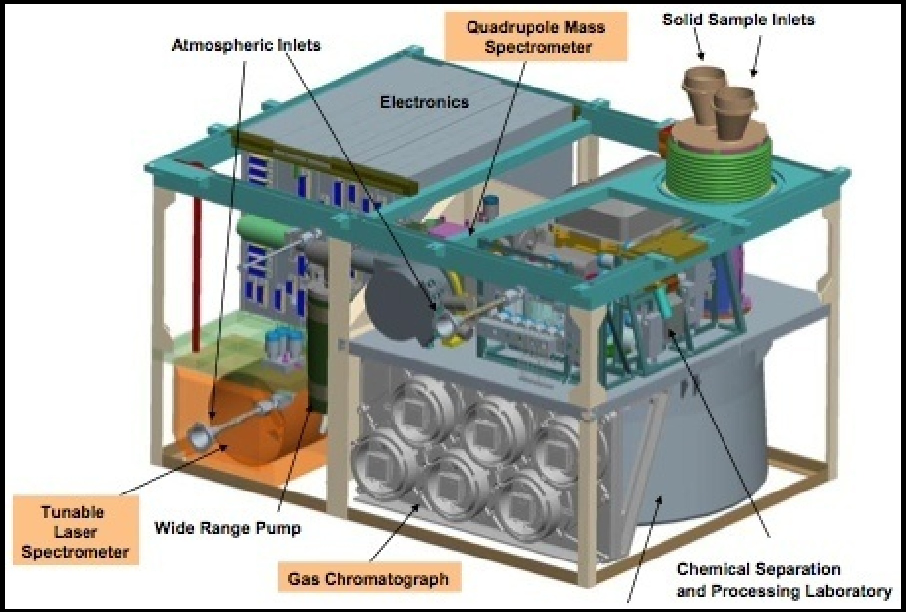
MSL Entry, Descent & Landing

MSL Ground Robotic Science

Dynamic Albedo of Neutrons (DAN)

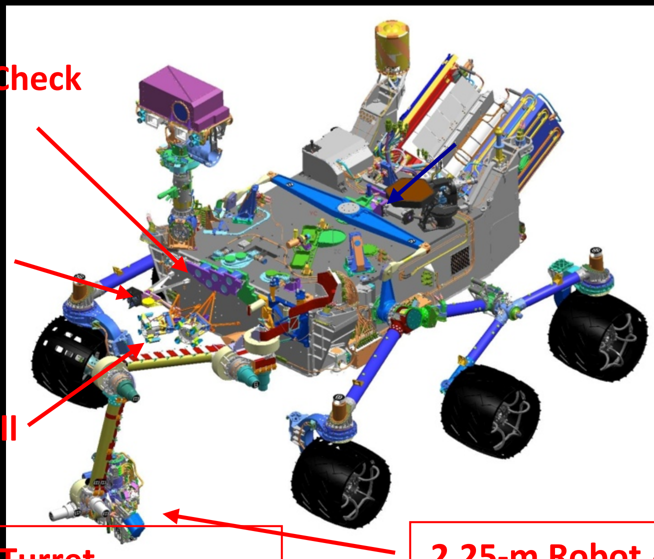


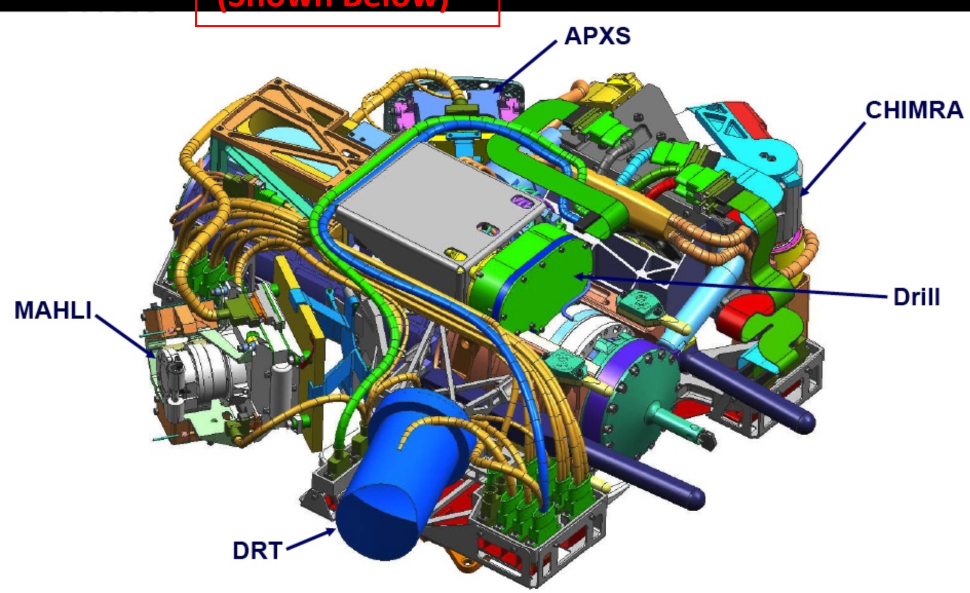
Alpha Particle X-ray Spectrometer (APXS)



Sample Analysis at Mars (SAM)

Sample Acquisition, Processing, and Handling





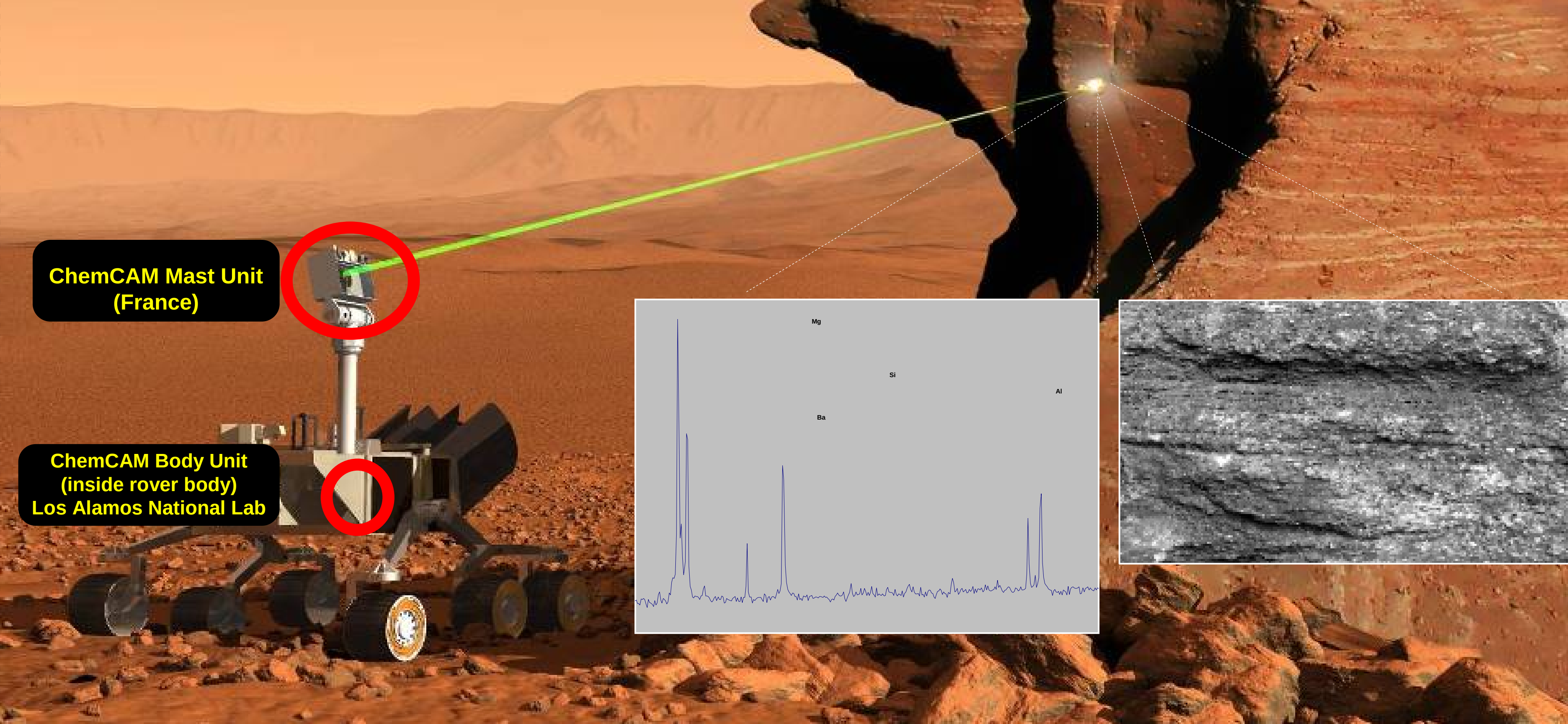
MSL's sampling system can:

- Clean rock surfaces with a brush
- Place and hold the instruments on the arm (APXS and MAHLI)
- Acquire samples of rock or soil with a powdering drill or scoop
- Sieve the samples and deliver them to SAM, CheMin, or a tray for observation
- Exchange spare drill bits

ChemCam is a Laser Induced Breakdown Spectroscopy (LIBS) Instrument with Remote Macroscopic Imaging (RMI) capability.

Principal Investigator: Roger C. Wiens
Los Alamos National Laboratory

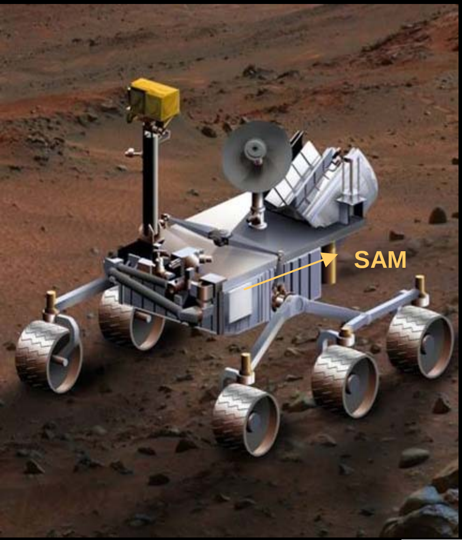
Deputy Principal Investigator: Sylvestre Maurice
Centre d'Etude Spatiale des Rayonnements (CESR)



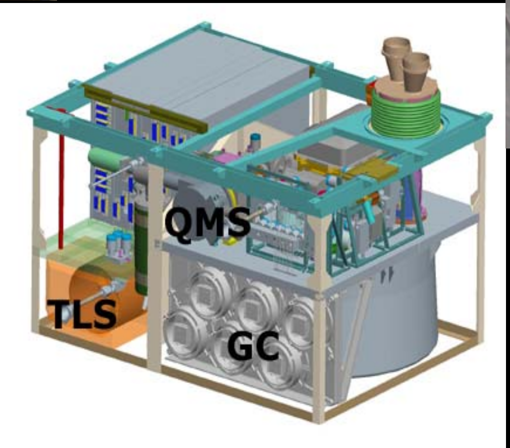
Sample Analysis at Mars (SAM) gas chromatograph can detect organic compounds

Gas Chromatograph (GC)

The GC columns can separate out individual gases from a complex mixture into molecular components for Quadrupole Mass Spectrometer and stand alone GC-mass spectrometry (GC-MS) analysis. A wide range of organic compounds including some of those relevant to life (amino acids, nucleobases, carboxylic acids, amines) can be detected by GC-MS.

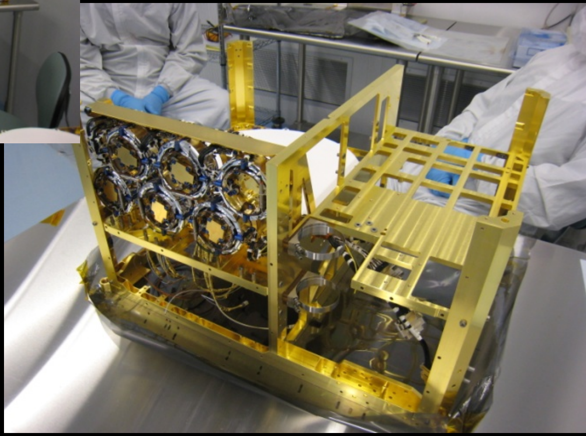


Location of SAM on Mars Science Laboratory rover



SAM configuration

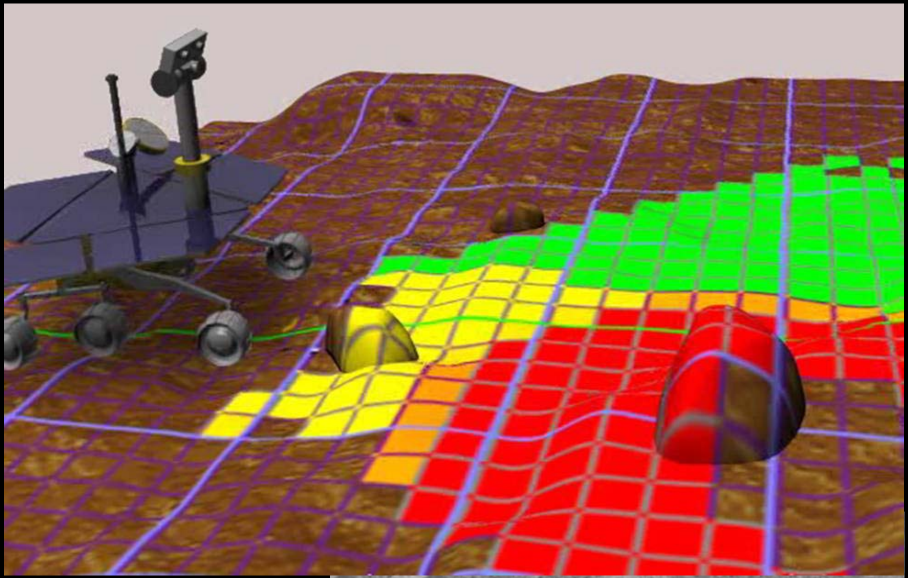
SAM engineers holding GC



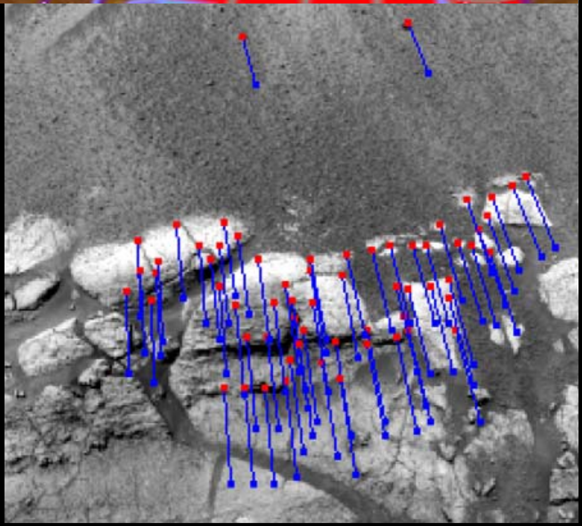
GC integrated onto SAM flight hardware

MER Driving Autonomy

- Terrain assessment (predictive hazard detection)
- Path selection
- Visual pose update (visual odometry)

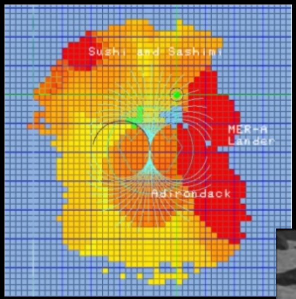


GESTALT Navigation



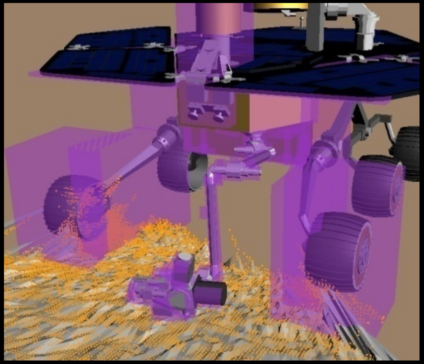
Visual Odometry

Autonomous Rover Surface Operations

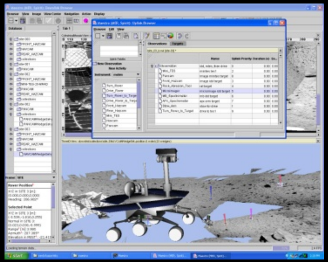


Actual map built from MER Spirit imagery

Visual Odometry



Simulation of autonomous instrument placement



Remote Science Operations

Key capabilities that provide autonomous operation of rovers millions of miles away

•Autonomous rover navigation

•Autonomous driving capability using stereo images for hazard detection and avoidance. The onboard software performs traversability analysis on 3-D range data to predict vehicle safety at all nearby locations; robust to partial sensor data and imprecise position estimation

•Visual odometry

•Capability to autonomously measure the progress of the rover traverse by imaging the surrounding area and comparing the successive images to provide an independent odometry from what is measured by the rotation of wheels to account for wheel slippage

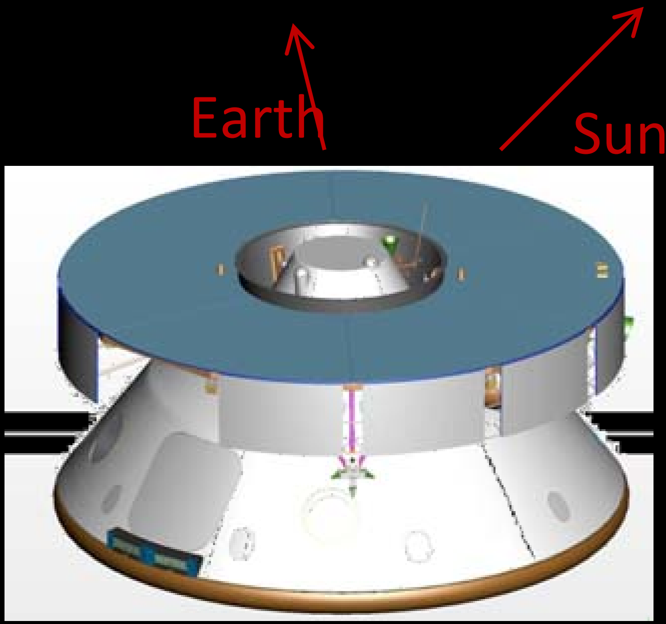
•Instrument placement

•Capability to autonomously traverse ~10 meters towards a rock designated by scientists and orienting the rover such that an instrument can be placed on the rock with ~1 cm accuracy. The onboard software uses visual tracking of the designated rock and autonomously drives the rover towards the rock while avoiding hazards and computes a feasible rover orientation so that its manipulator can place the instrument on the rock.

•Remote science operations

•Provides downlink data visualization, science activity planning, merging of science plans from multiple scientists and develops plans for autonomous science operations by the rover and its science instruments

General Spacecraft Autonomy and Fault Protection



- The spacecraft independently monitors its state and acts to maintain critical resources and capabilities:
  - Attitude (e.g. knowledge with respect to sun or stars, control based on available actuators)
  - Power (e.g. solar cell orientation to sun, power states)
  - Thermal (e.g. body orientation to sun, state of heaters, power states)
  - Communications (e.g. antenna orientation to Earth, configuration of radios)

- Onboard systems generally execute sequences of timed activities to control the spacecraft.
- Activities may include critical events like propulsive maneuvers with state monitors and decision-making. For example:
  - Inertial measurement of accumulated Delta-V
  - Monitoring for failed hardware and trigger of autonomous recovery.

Autonomous Underwater Vehicle

Environmentally
Non-Disturbing
Under-ice Robotic
Antarctic Explorer
(ENDURANCE)

Possible future submersible seeking liquid water on Europa or Enceladus

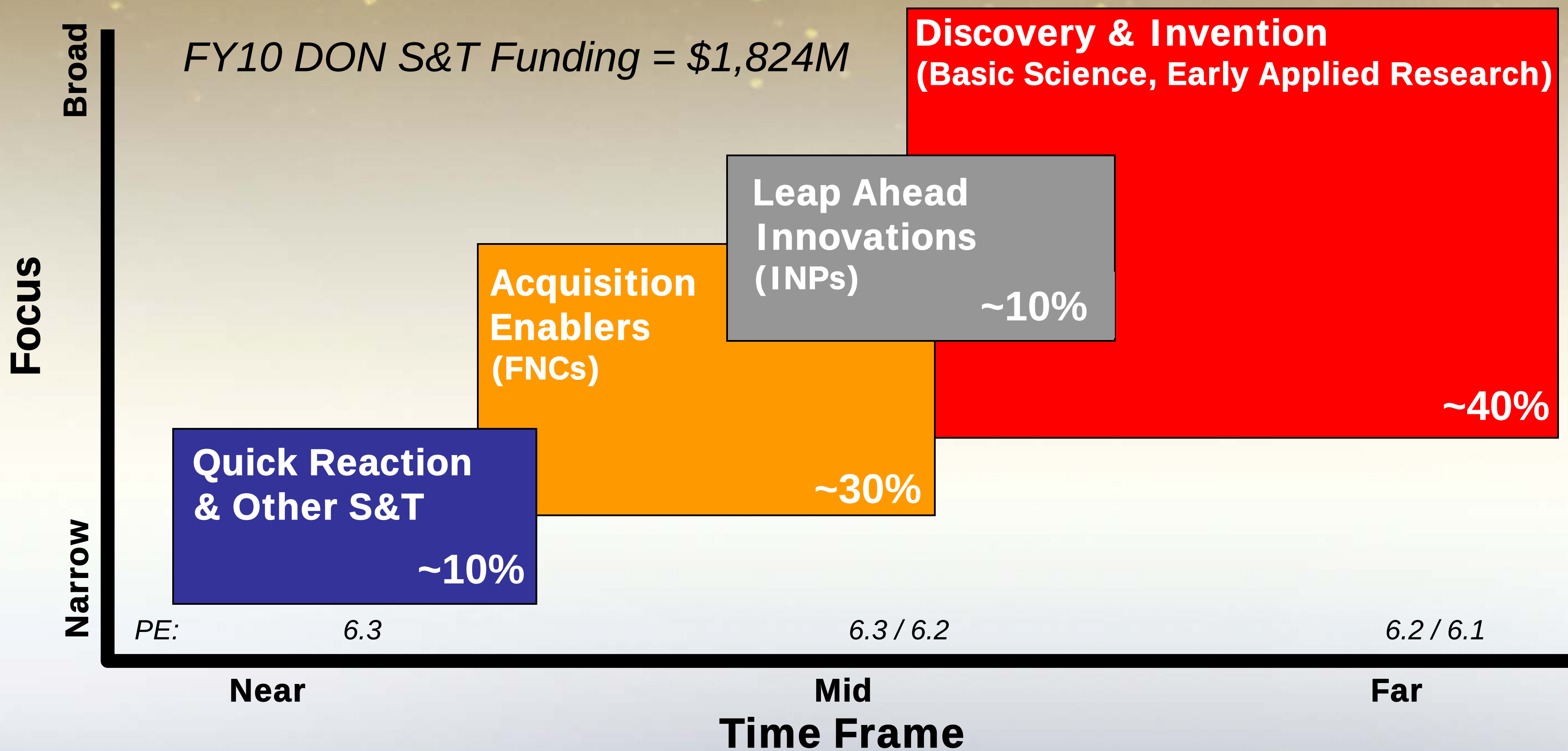
Ground Robotics Capability Conference and Exhibit

Mr. George Solhan

Office of Naval Research
Code 30

18 March 2010

S&T Focused on Naval Needs



Quick Reaction
(10%)
- Tech Solutions
- Experimentation
- MC S&T (MCWL, JNLW, etc.)

Acquisition Enablers
(36%)
- Future Naval Capabilities
- Warfighter Protection
- Capable Manpower
- LO/CLO

Leap-Ahead Innovations
(12%)
- Innovative Naval Prototypes
- NSPs
- Swampworks

Discovery & Invention
(42%)
- Basic & Early Applied Research
- National Naval Responsibilities
- Education Outreach HBCU/MI

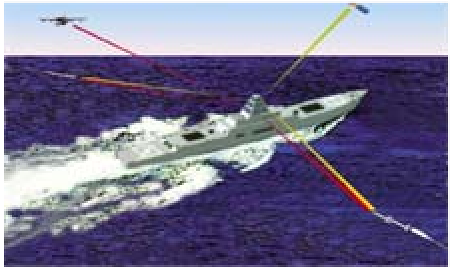
ONR S&T Departments

Code 30

Expeditionary Maneuver Warfare & Combating Terrorism

Code 31

C4ISR



Code 32

Ocean Battlespace Sensing

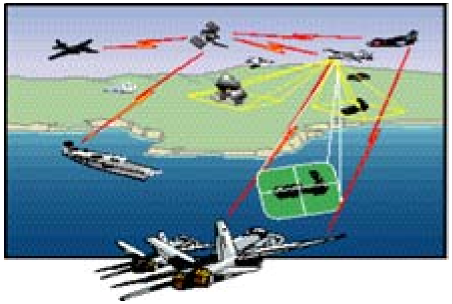
Sea Warfare and Weapons

Code 33

Warfighter Performance

Code 34

Air Warfare and Weapons



Code 35

ONR 30 Organization

Revolutionary Research . . .

Expeditionary Maneuver Warfare and Combating Terrorism S&T

Human, Social, Cultural, and Behavioral Sciences (HSCB)

Hybrid Complex Warfare Sciences Division (301)

- Basic Research Counter IED

Applications Division (302)

- FITE JCTD

Combating Terrorism & Integration Division (303)

- Maritime Irregular Warfare
- Operational Adaptation + HSCB

FY2011 R2 Activity Areas & ONR Code 30 Thrust Areas

ONR Code 30 Technology Investment Areas – Focused Thrust Level S&T Investments

HPT&E* Thrust
- ✓ Enhanced Physical Readiness
- ✓ Mental Resilience & Cognitive Agility
- ✓ Expertise Development

C4 Thrust
- ✓ Network Centric Warfare -Interoperability
- ✓ Over-The-Horizon Comms & Gateways
- ✓ Small Unit Technologies

ISR Thrust
- ✓ Persistent ISR
- ✓ Knowledge Generation
- ✓ ISR - C2 (Actionable Intelligence)
- ✓ Biometrics
- ✓ Tag, Track & Locate

Fires Thrust
- ✓ Targeting & Engagement
- ✓ Advanced Ammo
- ✓ Advanced Weapons

Logistics Thrust
- ✓ Asset Visibility
- ✓ Logistics Transport
- ✓ Operational Self-Sufficiency
- ✓ Maintenance Reduction
- ✓ Infrastructure

Maneuver Thrust
- ✓ Survivability
- ✓ Advanced Mobility
- ✓ Maneuver Enablers

Force Protection Thrust
- ✓ Detection
- ✓ Neutralization
- ✓ Mitigation

* HUMAN PERFORMANCE, TRAINING & EDUCATION

State-of-the Art

Current state of technology:

Navigation behaviors employing GPS based Route Network Definition Files (RNDF) and costly, multi-modal sensor suites

- ➢ Simple behaviors employing rule-based system
- ➢ Rule-based systems are not robust enough for complex environments when encountering uncertainty, imprecision, contradiction, and incompleteness
- ➢ Typical sensor suite and CPU cost often exceed $250K, bulky, power hungry
    - ❖ Limited environmental context and understanding outside of a pre-planned, structured environment
    - ❖ Sensor suite and CPU alone render capability un-affordable

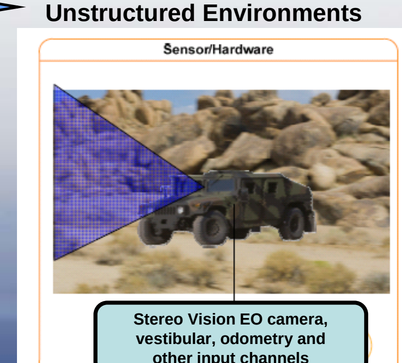
S&T challenges:

1. ***Affordable Logic/Software***
2. ***Affordable Sensor Suites***
3. ***Advanced Autonomy Algorithms***
4. Small unit mobility/maneuverability in extremely complex terrain
5. Dense power and energy devices/sources
6. Fuel independence/energy self-sufficiency for extended ranges

DARPA Urban Challenge

Advanced perception system and algorithms to reduce number of sensors and to allow operations in unstructured environments

Future Tactical System in Unstructured Environments



Remote Control Versus Autonomy

Revolutionary Research . . . Relevant Results

Remote Control

Operator continuously, visually controls the platform via tether or radio. UMS takes no initiative.

Tele-operation

Operator, using video or other sensor input either directly controls the platform or assigns incremental goals via tether or radio. In this mode, the UMS may take limited initiative in reaching the assigned incremental goals.

Semi-autonomous

Operator and the UMS cooperatively plan and conduct a mission but still requires varying degrees of Human-Machine Interface

Fully autonomous

A mode of operation wherein the UMS is expected to accomplish its mission, within a defined scope, without human intervention. Note that a team of UMSs may be fully autonomous while the individual team members may not be due to the needs to coordinate during the execution of team missions.

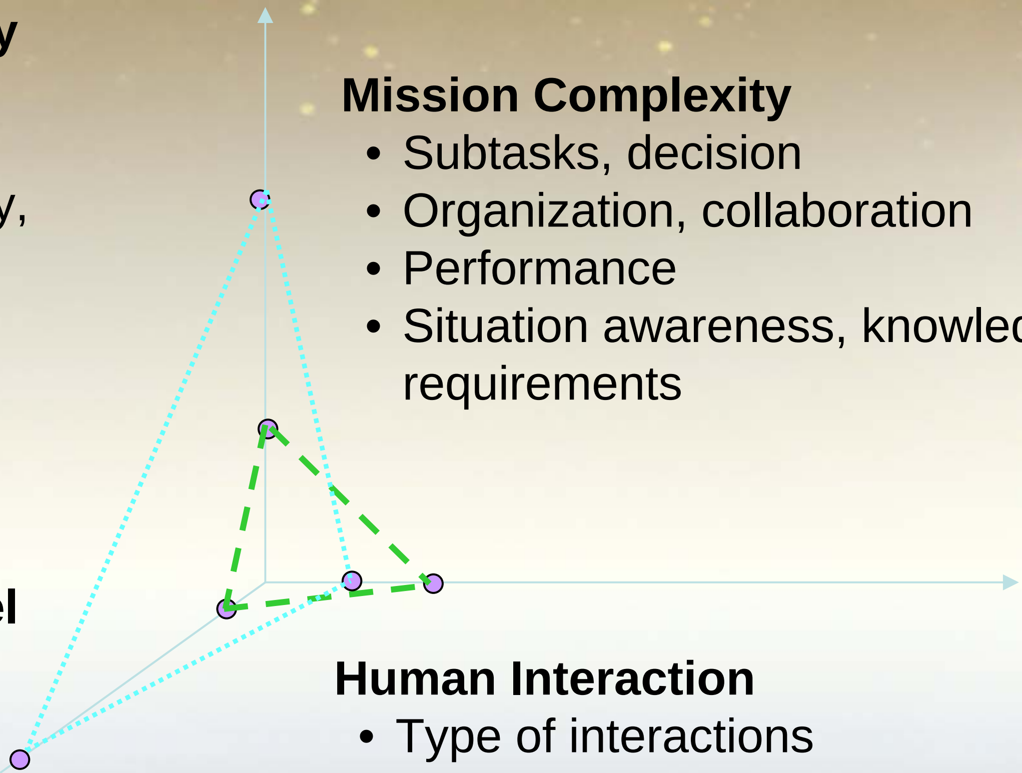
NIST Special Publication 1011
Autonomy Levels for Unmanned Systems (ALFUS) Framework
Volume I: Terminology
Version 1.1
September 2004

Why Autonomous Behavior is a Hard Problem

Environmental Complexity

Solution ratios on:
- Terrain variation
- Object frequency, density, intent
- Weather
- Mobility constraints
- Communication dependencies

Mission Complexity
- Subtasks, decision
- Organization, collaboration
- Performance
- Situation awareness, knowledge requirements



Machine Intelligence Level

Ability to:
- Reason, Plan, Predict
- Learn from experience, instructions, etc., and adapt to new situations
- Understand the battlespace
- High-level interactions with humans

Human Interaction
- Type of interactions
- Type of operators/users (e.g., workload, skill levels, etc.)
- Frequency, duration, robot initiated interactions

ONR 30 Unmanned Ground Systems
Areas of Interest

Affordable Sensor Suites and Advanced Perception System

Move away from costly multi-modal sensors suites to low-cost vision based sensors

a. Leverage existing machine vision work performed by DARPA and JPL (LAGR Program)
b. Distributed computing networks to process "at-the-sensor " utilizing FPA, DSP, GPU and reduce the computational burden on the CPU
c. More capable and robust texture analysis algorithms (segmentation, texture, signature)
d. Reasoning algorithms to discriminate between objects and apply context to a near-field spatial scene (rock-bush, puddle-hole, door-window)

Advanced Autonomy Algorithms

Move from point-to-point navigation to autonomous behaviors not reliant on GPS

a. Near-field Tactical Path Planner utilizing a Raster World Model including relative and absolute localization (SLAM)
b. Far-field Advanced Path Planner to include platform master state information and environmental traversability
c. Dynamically generated high-level situation awareness model incorporating information not organic to the vehicle such as threat areas, road and terrain connectivity and traversability, and real-time events and intelligence (Ford Sync System™)
d. Advanced autonomy behaviors which integrate bottom-up perception and top-down reasoning to execute doctrinally correct tasks with no human intervention

ONR Unmanned Systems POC's

- ONR 30: (Bradel)
  - *Genetic Programming/Auto-Code Generation*
  - *Advanced Perception Algorithms for Vision-Based Sensors*
  - *Advanced Autonomy Algorithms for UGV's*
- ONR 31: (Kamgar-Parsi)
  - *Image Understanding*
  - *Robotic perception*
  - *Machine reasoning and planning in uncertain environments*
- ONR 32: (Swean)
  - *Unmanned Underwater Systems*
- ONR 33: (Brizzolara)
  - *Intelligent Autonomy for USSV*
  - *Developing Autonomy for USVs by Using Virtual Environments*
- ONR 34: (McKenna)
  - *Human-Centric Autonomy*
  - *Natural-language Dialogue with Autonomous Systems*
  - *Human Tracking and Activity Recognition*
- ONR 35: (Steinberg)
  - *Intelligent Autonomy for UAS*
  - *UAS Mission Control Interfaces*
- Naval Research Lab (Schultz)
  - *Artificial Intelligence*

How to contact ONR

For more information about ONR:

http://www.onr.navy.mil/

For more information on Unmanned Ground Systems, contact ONR Code 30 at:

http://www.onr.navy.mil/Home/Science-Technology/Departments/Code-30.aspx

To submit a white paper:

http://www.onr.navy.mil/

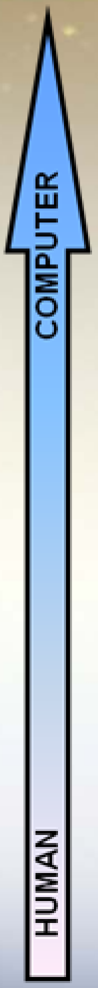
Click on “Contracts and Grants”
Click on “Broad Agency Announcements”
Select “BAA10-001”

Questions?

Back-Up Slide

Revolutionary Research . . . Relevant Results

Man versus Machine



Level	Observe	Orient	Decide	Act
8	The computer is responsible for gathering and filtering data without displaying any information to the human.	The computer overlays predictions with analysis and interprets data for a result that is not displayed to the human.	The computer performs the final ranking task, and does not display the result to the human.	The computer executes the decision and does not allow any human interaction.
7	The computer is responsible for gathering and filtering data without displaying any information to the human. Though, a "program status indicator" is displayed.	The computer overlays predictions with analysis and interprets data for a result which is only displayed to the human if result fits programmed context (context dependant summaries).	The computer performs the final ranking task and displays a reduced set of ranked options without displaying "why" the decision was made to the human.	The computer executes the decision and only informs the human if required by context. The human is given override ability after execution when physically possible.
6	The computer is responsible for gathering, filtering, and prioritizing information displayed to the human.	The computer overlays predictions with analysis and interprets the data. The human is shown all results for potential override.	The computer performs the ranking task and displays a reduced set of ranked options while displaying "why" the decision was made to the human.	The computer executes the decision, informs the human, and allows for override ability after execution when physically possible. In the event of a contingency, the human can independently execute the decision.
5	The computer is responsible for gathering and displaying unprioritized information to the human. The computer filters out the unhighlighted data displayed to the human.	The computer overlays predictions with analysis and interprets data. The human is the backup for interpreting data.	The computer performs the ranking task. All results, including "why" the decision was made, are displayed to the human.	The computer allows the human a context-dependant time-to-veto before executing the decision. In the event of a contingency, the human can independently execute the decision.
4	The computer is responsible for gathering and displaying unfiltered, unprioritized information to the human. The computer highlights the relevant non-prioritized information displayed to the human.	The computer is the prime source for analyzing data and making predictions as a trusted calculator. The human is the prime source for interpreting data.	Both the human and the computer perform the ranking task, the results from the computer are considered prime.	The computer allows the human a pre-programmed time-to-veto before executing the decision. In the event of a contingency, the human can independently execute the decision.
3	The computer is responsible for gathering and displaying unfiltered, unhighlighted, and unprioritized information to the human. The human is responsible for filtering and prioritizing the data, with computer backup.	The computer is the prime source for analyzing data and making predictions with human checks of the calculations. The human is the only source for interpreting data.	Both the human and the computer perform the ranking task, the results from the human are considered prime.	The computer executes the decision after human grants authority-to-proceed. In the event of a contingency, the human can independently execute the decision.
2	The human is the prime source for gathering, filtering, and prioritizing data, with computer backup.	The human is the prime source for analyzing data and making predictions, with computer verification when needed. The human is the only source for interpreting data.	The human is the only source for performing the ranking task, but the computer can be used as a tool for assistance.	The human is the prime source for executing the decision, with computer backup for contingencies (e.g. deconditioned humans).
1	The human is the only source for gathering, filtering, and prioritizing data.	The human is the only source for analyzing data, making predictions, and interpreting data.	The human is the only source for performing the ranking task.	The human is the only source for executing the decision.

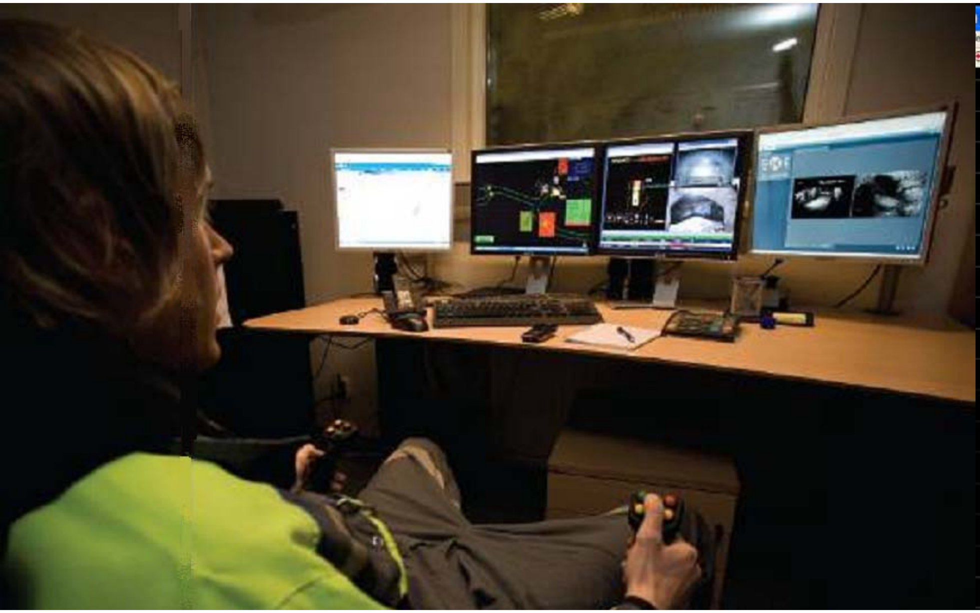
NASA FLOOAT (Function-specific Level of Autonomy and Automation Tool)

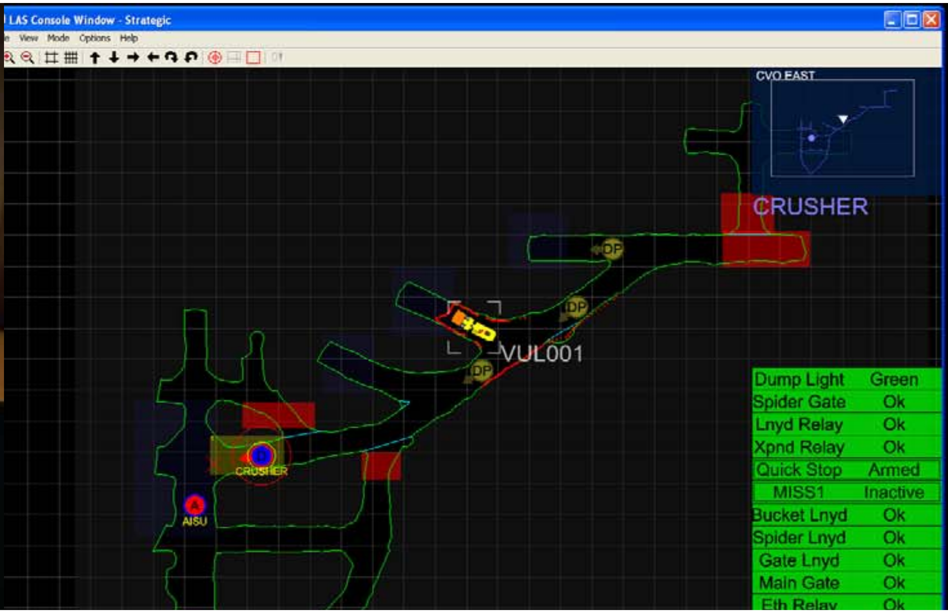
Mining Automation

Mining safely. Mining more. Mining right.

CATERPILLAR®

Mining’s Production Robots





Mines

Cat

Sandvik

Automation Benefits:

- Improved Safety
- Fewer resources
- Less machine damage
- Higher utilization

Mining's Production Robots

Komatsu

Freeport

Rio Tinto / CRC Mining

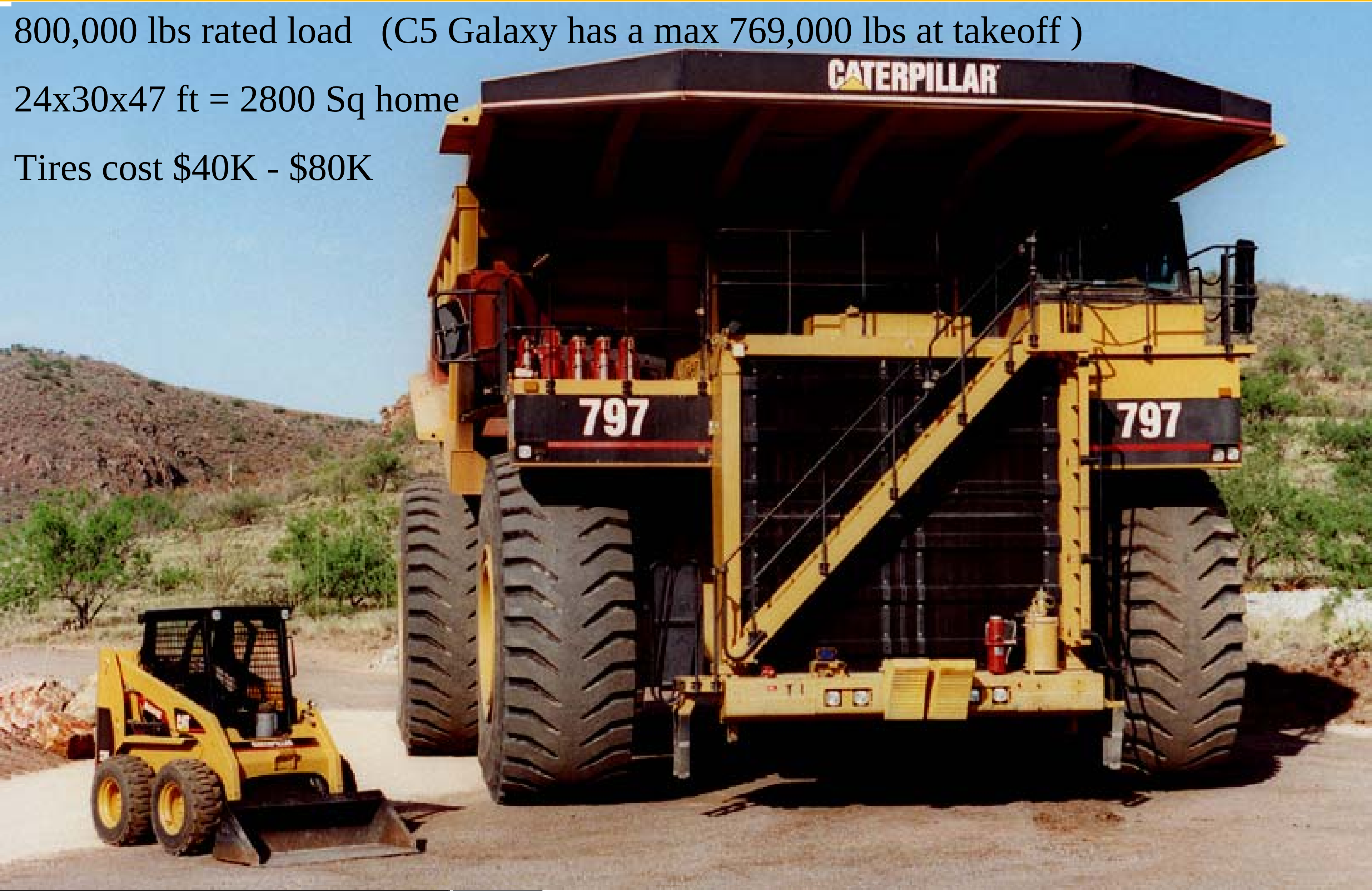
Cat D10T

Caterpillar’s Robots in Development

800,000 lbs rated load (C5 Galaxy has a max 769,000 lbs at takeoff)

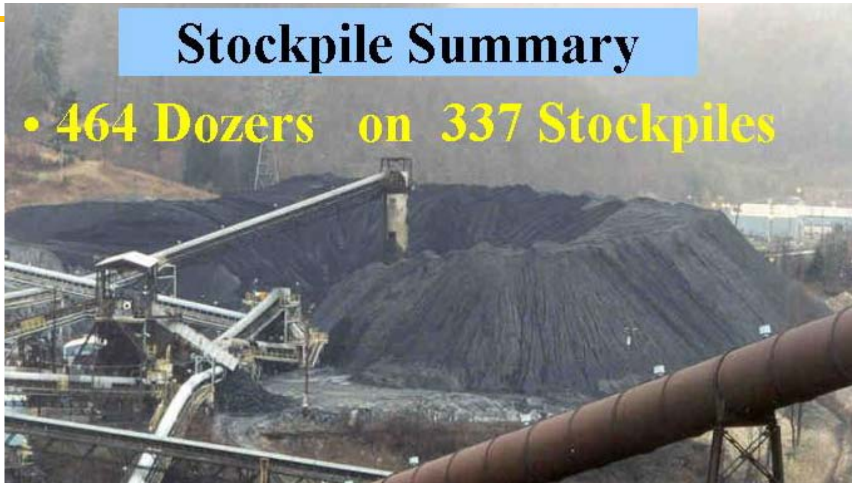
24x30x47 ft = 2800 Sq home

Tires cost $40K - $80K



Drivers for Automation

NIOSH: 1 Fatality per Year



- Safety
- Lack of people / Location
  - Australian outback
  - 12,000 foot elevation
  - Canadian tar sands
- Utilization & Efficiency Gain
  - In a 24 hour operation, 15 – 16 hours of run time is the norm.
  - > 20% efficiency gain demonstrated in some cases

Future Vision

- Robots will certainly be the workhorse that drives future mining and allows the developing world to enjoy our standard of living.

- “FCS” like connectivity will provide transparency into the construction/mining operation to allow site level optimization – largely based on the consistency provided by automated machines & systems.

- Autonomous systems will work more efficiently with less environmental impact.
  - Up to 40% fuel savings per unit work
  - Increased utilization & productivity
  - Improved safety

Challenges

Product:

- In general our customers are not risk takers on technology
- Conditions are harsh > Mil Spec in many cases
- Reliability targets are high > 10X military
- Cost targets are low

Technical:

- Reliable Communications
- Reliable / consistent object detection (small rocks)
- Robust positioning in GPS shaded areas